POWER

Volume 54 New York, July 5, 1921 *Number* 1

OVERCONFIDENCE

By Rufus T. Strohm

IT'S mighty fine to have conceit, to stand erect upon your feet and meet your fellows squarely; to feel that you possess the grit and knowledge that will make you fit to earn a living fairly. But you must exercise restraint when you are called upon to paint your virtues to another; for if you show excess of pep and bounds of due reserve o'erstep, you'll gum the game, my brother.

Ham Bohn will illustrate the case. He called at Old Man Johnson's place because he'd heard a rumor that they could use an engineer; so he was moved to volunteer, he said in joking humor. The Old Man looked him up and down from sole of shoe to tip of crown and then demanded gruffly that he explain just why he thought that he could swing the job he sought, and sketch his training roughly.

Ham vowed that in his long career as stationary engineer no boiler had exploded; he never had a bearing heat, a bagging flue or fire sheet, nor e'en a plate corroded. Combustion and its chemistry to him were just like A B C to persons educated; he never had a plant stop dead so long as he was at the head, he rather proudly stated.

Mistakes with him would not occur, for he was never known to err concerning engineering; he knew by instinct what to do whenever troubles old or new began their interfering. He praised his fairness to his mates, his honesty and other traits too numerous to mention; and what they called Efficiency — he pointed out with boastful glee—that was his own invention!

The Old Man sadly shook his head. "You're too high-class for us," he said, "for we make errors often; and if you joined our staff, I guess your intellect and lonesomeness would drive you to your coffin. We've run this plant for quite a spell and think we've done it rather well, and while we do not doubt you, we hardly need a superman, and so we'll try as best we can to carry on without you."

Electric-Motor Drives for Pumps

Advantages of Reciprocating and Centrifugal Pumps—How to Figure Capacities and Power Required—Operating Characteristics—Types of Motor to Use for Different Kinds of Service

By GORDON FOX
Electrical Engineer, Freyn Brassert & Co., Chicago

PUMPING liquids is one of the most commonplace operations. As a large number of pumps are motor-driven the requirements and considerations involved are worthy of particular attention. Piston or plunger and centrifugal pumps are the two types most common and these differ widely in many respects. In all motor-driven reciprocating pumps having more than one plunger, the cranks are angularly displaced to equalize the liquid flow and power requirement. Reciprocating pumps are normally slow-speed machines, the crankshafts running at about 50 r.p.m. A gear reduction of about 4 to 1 is inserted usually between the crankshaft and the driven shaft, so that the latter revolves at about 200 r.p.m. The motor may be connected to this driven shaft through a belt, gear or silent chain.

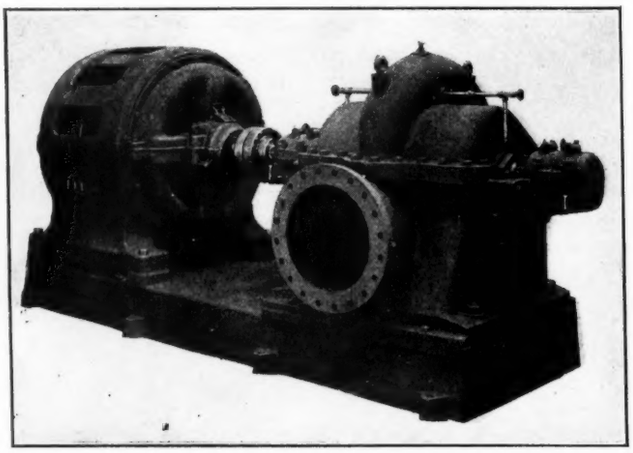


FIG. 1. SINGLE-STAGE LOW-HEAD VOLUTE CENTRIFUGAL PUMP

Centrifugal pumps are of two types, known as volute pumps (Fig. 1) and turbine pumps (Fig. 2). The former have a spiral casing forming a "whirlpool" chamber of gradually increasing size. They are employed commonly in low-head service up to 100 ft. Turbine pumps are provided with a series of diffusion vanes, or expanding ducts between the impeller and the casing, which convert the velocity head of the liquid into pressure head. They may have one or more stages, according to the head imposed, and, when the pumps are connected in series, as in Fig. 2, they may be operated against a static head up to 2,000 ft. or more.

Centrifugal pumps are inherently high-speed machines. The tendency is toward the highest possible speeds because the number of stages required is thereby reduced, decreasing the cost, and also because the efficiency of this type of pump is best at high speeds. This feature permits the direct connection of centrifugal pumps to high-speed motors, resulting in compact and relatively low-cost equipment.

Displacement pumps of the piston or plunger types have, in general, the following advantages: Their efficiency, except at low heads, is usually higher than that of centrifugal pumps. They may be employed for higher heads than are obtainable with centrifugal pumps. They are more simple where small quantities are required at high heads. They give positive delivery and will usually start without priming.

Centrifugal pumps have the following general advantages: They are simple, having a minimum number of wearing parts, and require little maintenance. Owing to high speeds, they are relatively small and compact and low in first cost. They will handle dirty water, sewage and water containing solids up to 40 per cent. They will not develop pressure beyond a predetermined amount in case the flow is shut off. They may, therefore, be used on closed hydraulic systems to maintain a fixed pressure, simply churning during the idle periods. They deliver a steady flow at uniform pressure. They permit the use of high-speed, efficient motors of low first cost and are more efficient than reciprocating pumps for low-head service. They will handle hot water to advantage.

Centrifugal pumps are used extensively for handling water containing sand, sewage, ashes and other solids. They are particularly well suited for low-head work such as for irrigation, drydock and cofferdam pumping, sump pumping, etc. They are used for boiler-feed purposes in the larger plants and for service pumping and a variety of miscellaneous applications. These pumps are at a disadvantage in that they have no suction unless primed. If they have a suction lift, a foot valve may be used, but a small leakage defeats its purpose. It is preferable for the water to enter the pump by gravity, eliminating priming difficulties. Centrifugal pumps cannot be used for liquids containing an excess of entrained air.

Capacities of piston or plunger pumps, in gallons per minute, may be found by the formula,

$$Q = \frac{\frac{1}{4} \times \pi \times D^2 \times N \times L \times K}{231} = 0.0034\, ND^2LK$$

where

Q = Capacity in gallons per minute;
N = Effective strokes per minute;
D = Diameter of piston or plunger in inches;
L = Length of stroke in inches;
K = Constant, a measure of the slip or leakage, which varies from 0.7 to 0.97, depending on conditions. An average value of K may be taken as 0.95.

The power required by any pump may be expressed by the formula,

$$HP = \frac{Q \times P}{1713 \times E}$$

where Q = Delivery, gallons per minute; P = Pressure, pounds per square inch; E = Efficiency of pump.

Average values of efficiencies at various heads for reciprocating pumps are as follows:

Head, feet	50	100	150	200	300	500	700
Efficiency, per cent	47	60	68	73.5	78	81	82

Very small pumps have efficiencies ranging as low as 25 per cent. Reciprocating pumps displace a fairly definite volume of liquid at each stroke. The following conditions therefore apply to pumps of this type:

Reduction of head affects volume very little.

Reduction of head affects the power required in direct proportion.

Variation in speed, against constant head, varies the volume in direct proportion.

Characteristics of Centrifugal Pumps

As the capacity of a centrifugal pump depends largely upon design details it cannot be determined by a general formula, but must be obtained from the pump manufacturer's rating or curves. The power required to drive a centrifugal pump is given by the same formula as that stated in connection with reciprocating pumps. The accompanying table gives approximate values of efficiency for various centrifugal pumps.

Operating characteristics of centrifugal pumps differ radically from those of reciprocating pumps. They follow these general rules:

With constant speed the volume will vary inversely as some function of the head, depending upon the pump design. Reduction of head causes great increase in volume delivered if the pump has a flat *QH* curve.

With a constant head applied, the volume will vary as some function of the pump speed, depending upon the pump design. Variation in speed causes relatively great change in volume if the pump has a flat *QH* curve.

The head developed by a centrifugal pump is proportional to the square of its speed.

The power required by a centrifugal pump is a function of its volume and head and may vary over wide limits as these vary.

As a general rule, head, speed and power are all somewhat variable, so that conditions may be considered only by means of characteristic curves. The characteristic curves of a given pump show the efficiency, power input and head developed, plotted as ordinates, against volume as abscissas. Fig. 3 shows the curve of a pump having a steep head-delivery characteristic, while Fig. 4 shows the characteristics of a pump having a flat head-delivery curve. The principal factor affecting the head-delivery characteristic of a centrifugal pump is the angle of the impeller blades at their tips. If the tips are radial or curved forward in the direction of rotation, the head will increase as the delivery increases. If the blades curve backward sufficiently, the head will remain approximately constant or will fall off with an increase of delivery. In a pumping system the head comprises:

1. Suction lift if the supply is below, or suction head if the supply is above the pump. This may be somewhat variable.

2. Static head or elevation of the water column in the system. This may vary between limits.

3. Friction head, due to friction in the pipes, fittings and valves. This is determined from tables of losses in pipe lines and fittings and varies with the volume.

4. Velocity head, $H = V^2 \div 64.4$, where V is the discharge velocity in feet per second at the discharge nozzle of the pump.

The head of a system is commonly represented by a curve, as in Fig. 5, which shows the static head with no flow and the head increasing with the flow. The friction head in piping must not be neglected, lest the volume delivered by a centrifugal pump fall short of that desired or the motor driving a reciprocating pump be overloaded. The head developed by a pump must equal the head of the system on which it is working, to give a condition of equilibrium. Hence, if the curve of the system head is superimposed upon the curve of the pump head, the point of intersection represents the condition of equilibrium and the corresponding volume gives the flow which will occur under the given condition. The corresponding horsepower, *HP*, also may then be read from the curve.

To determine the effect of changed conditions, new curves should be plotted and the corresponding balance point determined. If a change is made in the system head by throttling the discharge, the dynamic head will be increased, so that the system-head curve will bend upward more rapidly and a condition of equilibrium will occur at a lower volume and lesser power input. If the change is in the static head, as by a change in standpipe level, the system head curve will have its original curvature, but will be higher or lower by an amount corresponding to the change in static head. If the static head fluctuates between limits, the two system-head curves may be plotted corresponding to these limits and the points of balance or limiting operating conditions be determined.

Pump Head and Horsepower at Different Speeds

A change in pump speed causes a change in head developed by the pump and also a change in volume. To determine the head for a pump at speeds other than normal, say at 110 per cent of normal speed, multiply any normal value of head by 1.10^2, and multiply the volume corresponding to the value of the normal head selected by 1.10 to give the new volume. Plot the new values of head and volume to give one point on the new head-delivery curve. Do likewise to obtain other points. Comparing the new curve with the system-head curve will show the condition of balance or the new operating condition. To obtain the approximate horsepower required at different speeds, proceed as follows: First determine the volume at the increased or reduced speed from

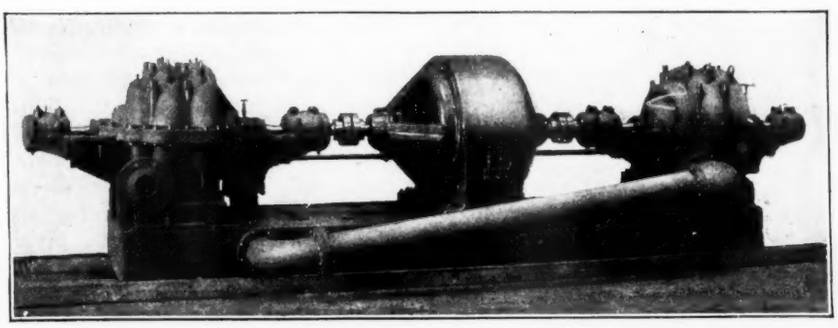


FIG. 2. MULTI-STAGE TURBINE-TYPE CENTRIFUGAL PUMP FOR HIGH-PRESSURE

the curves, as previously described. Multiply this volume by the fraction, $\frac{Normal\ speed}{New\ speed}$. The power corresponding to the volume thus found may be taken from the normal characteristic curves. Multiply the power value thus found by the cube of the fraction, $\frac{New\ speed}{Normal\ speed}$. The result is the horsepower required at the new speed.

Any centrifugal pump has its highest efficiency at some definite speed, usually corresponding to the rated speed. Volute pumps retain fair efficiency over a range of speeds. On high-pressure turbine pumps any departure from the most efficient speed is usually attended by a considerable decrease in efficiency.

Direct-Current Drive

Pumps are driven by several types of motors, notably shunt and compound-wound motors with constant- and adjustable-speed ratings, induction motors of squirrel-cage and wound-rotor types, and synchronous motors. The proper motor selection involves the type of pump, nature of service and electric system available. The majority of pumps operate at constant speed, but adjustable speed is often desirable to vary the output or pressure or to adapt the pump to changes in head of the system.

Where constant speed is desired, the motor, if for direct current, may be either a shunt- or compound-wound machine. The shunt motor is satisfactory for constant-head constant-capacity conditions definitely maintained. The compound-wound motor may be preferable for reciprocating pumps starting under load and for centrifugal pumps where the load fluctuates, since the compound-wound winding will drop the speed

FIG. 3. CHARACTERISTIC OF PUMP HAVING STEEP DELIVERY-HEAD CURVE

with load increase and protect the motor against overload. The compound-wound motor also has some advantage where the system voltage fluctuates, in that it tends to maintain more uniform speed.

If alternating current is available, the squirrel-cage motor more often is used. The 60-cycle system has here a measure of advantage in that somewhat higher-speed motors are available. The slip-ring motor is applied where a small range of speed control is desired, where starting conditions are severe, as with reciprocating pumps starting under load, where drooping speed regulation is desired, and where the motor is large compared with the system upon which it operates. Use of the synchronous motor is feasible only upon the

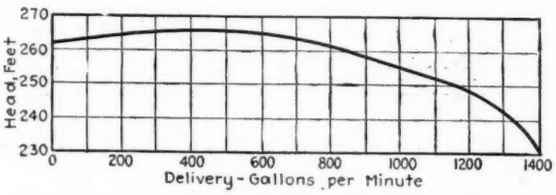


FIG. 4. CHARACTERISTIC OF PUMP HAVING FLAT DELIVERY-HEAD CURVE

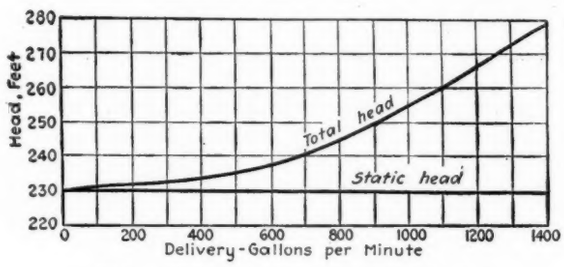


FIG. 5. CURVE OF SYSTEM HEAD

larger pumps, notably the larger centrifugal pumps operating uninterruptedly at constant speed against constant head. The starting conditions must be carefully considered.

Control of Pump Delivery

Speed adjustment of pumps may be obtained through armature or field control of direct-current motors or through secondary resistance control of wound-rotor induction motors. The polyphase commutator-type motor with the brush-shifting device is sometimes used to obtain adjustable-speed drive for the larger-sized pumps. A reciprocating pump working against a given head requires constant torque at any speed and the horsepower required is in proportion to the speed. A centrifugal pump working against constant head, increases its horsepower demand approximately as the square of the speed. Adjustable-speed motors driving pumps will ordinarily deliver maximum power at maximum speed. At the lower speed, which determines the motor rating on a heating basis, the power requirement is reduced. It is, therefore, permissible to motor closely in this case.

Armature- or secondary-resistance control is less efficient and does not produce constant speed under fluctuating-load conditions. It may be used, however, and has in its favor the decrease in load with decrease in speed, minimizing the losses. The resistors must be proportioned to take into account the decreased loading at reduced speeds. This arrangement is not uncommon, using the wound-rotor induction motor, but where direct current is available, the adjustable-speed motor is generally to be preferred.

Where a standpipe or other sufficient storage provision occurs, the delivery of a given constant-speed pump may be varied by operating the pump intermittently, automatic control being provided and this in turn being governed by a float or pressure switch. This arrangement necessitates starting the pump under load. It also requires a storage sufficient, with respect to pump

capacity and service demand, so that the periods of pumping and rest will not be of too short duration.

As stated in the foregoing, the load taken by a centrifugal pump varies rapidly with change in speed. For this reason any condition causing a speed increase may lead to overloading the motor. Such conditions might arise from high frequency, motor speed above rating, slight discrepancy between rated motor speed and rated pump speed, or motor-speed increase due to field heating.

In the majority of pump drives constant head and constant capacity are desired. If this is not the case, the range of conditions to be met must be considered. Reduction in volume against constant head can be obtained with a reciprocating pump by reduction in speed or by an overflow provision. In the case of a centrifugal pump delivery can be reduced by reducing the speed or by throttling, which increases the head at the pump and decreases the volume. If a centrifugal pump has a flat head-delivery curve, a small increase in system head obtained by throttling will cause a relatively great decrease in delivery. The efficiency at decreased output is then but little less than that at full output. If a pump has a steep head-delivery curve, it is necessary to increase greatly the system head by throttling in order to reduce the discharge. The efficiency at reduced output is relatively low.

EFFICIENCY OF CENTRIFUGAL UMPS

Gal. per Min.	Head, Ft.	Efficiency, Per Cent
100	10 to 50	25 to 50
500	10	50
500	20	60
500	50 up	65
1,000	10	55
1,000	20	63
1,000	50 up	68
2 000	10	58
2,000	20	65
2,000	50 up	70
4,000	10	60
4 000	20	65
4,000	50 up	72
8,000	10	63
8 000	20	70
8,000	50 up	76

A comparison of relative efficiency of control of delivery by throttling as compared with variation of motor and pump speed, using armature or rotor resistance, must be based on the fact that the motor efficiency falls off approximately in direct proportion to the slip, whereas the over-all pumping efficiency with throttled discharge will vary according to the pump characteristic, as previously described. If a pump is to be operated for long periods at reduced delivery, it is advisable to calculate the power input to the motor for both methods and determine whether the saving, if any, by using variable-speed drive, will justify the greater investment required.

A centrifugal pump delivers a greater volume at heads below rating and, in so doing, requires more than normal driving power. Pumps having a steep head-delivery curve will not vary the delivery very much except with a marked change of head. Pumps with a flat head-delivery curve may discharge widely different volumes with slight changes in head. Some pumps are so designed as to limit the load requirements even with low head, within limits of 125 per cent of the normal motor load. A compound-wound or a wound-rotor motor with permanent slip resistance may be used to afford a degree of protection in that the speed on overload will drop sufficiently to prevent conditions of excessive loading.

Starting Torque Required for Reciprocating and Centrifugal Pumps

In starting from rest a reciprocating pump connected to the system requires full pump torque plus friction and accelerating torques and thus creates a severe starting condition. It is preferable to unload the pump during the starting interval, bypassing the cylinders, so that the water is merely circulated against a negligible head.

Generally speaking, the only load taken in starting a centrifugal pump from rest is the bearing friction and pump inertia, both relatively small items. As the speed increases the load increases about as the cube of the speed. If the pump is started with the discharge valve closed, the load increases as above, up to the full-speed zero-discharge load (churning load) on the characteristic curve. If the pump is started with the discharge valve open, the load increases about as the cube of the speed up to full-speed full-discharge value for the then existing head. If the head on a centrifugal pump is largely static, the pump will not start delivery until nearly up to speed, so that relatively the starting conditions will be favorable. If the head is largely from friction, as in dredging work, the pump will start to discharge at low speed and will accelerate under rather heavy load. It is desirable to start the larger centrifugal pumps with the discharge valve closed in order to relieve the starting conditions. It is evident from the foregoing that the starting conditions for different pumps may vary considerably.

In applying a self-starting synchronous motor to a centrifugal pump drive, the pull-in torque is a major consideration, being much greater than the starting torque required. The pump should be started with the discharge valve closed. The pull-in torque then required for churning conditions will be about 50 per cent of the full-load torque. High-speed synchronous motors will develop this amount of torque without an excess inrush of current. However, starting conditions should be checked whenever synchronous motors are to drive centrifugal pumps to make sure that the motor characteristics are suited to the drive. The application of synchronous motors to centrifugal pumps is restricted to some extent by the lack of suitable high-speed motors. If it is necessary to use a lower-speed pump because a high-speed motor is not available, the pump cost is materially increased, likely beyond a margin justifiable by the benefits to be derived from the use of a synchronous motor.

An opportunity for those who are handy with a camera is given by the Powergraph Page. Anyone who likes to take photographs and who works around a power plant should be able to find a subject that would make a good Powergraph every once in a while. By taking such pictures and sending them in, a man can make some extra money and have the satisfaction of seeing his work displayed in *Power*. The ideal Powergraph is striking enough to catch a reader's attention and practical enough to tell him a useful story. It shouldn't be hard to find some in your plant. Why not try your hand at it?

Jennings Turbine-Driven Return-Line Heating Pump

A novel type of steam-turbine-driven return-line heating pump, the general design of which is shown by Fig. 1, consists of an air pump that exhausts the air from the system, a centrifugal pump to remove the hot condensate and return it to a feed-water heater or hotwell and a steam turbine to drive the unit—all mounted on one shaft, Fig. 2, and assembled in the same casing.

This unit, which is manufactured by the Nash Engineering Co., South Norwalk, Conn., is especially designed for use in connection with heating or drying systems where the pump is called upon to maintain a vacuum on the heating system and to return the hot water and condensation against a pressure. The unit consists of two independent turbine pumps built in one casing, one pump handling the air and the other the condensation, the air and condensation being separated in a receiver, Fig. 3, under vacuum before entering the unit. This arrangement makes possible a saving in power, because the condensation, which is only one-eighth of the volume handled, is alone delivered against the discharge pressure, the air being delivered free

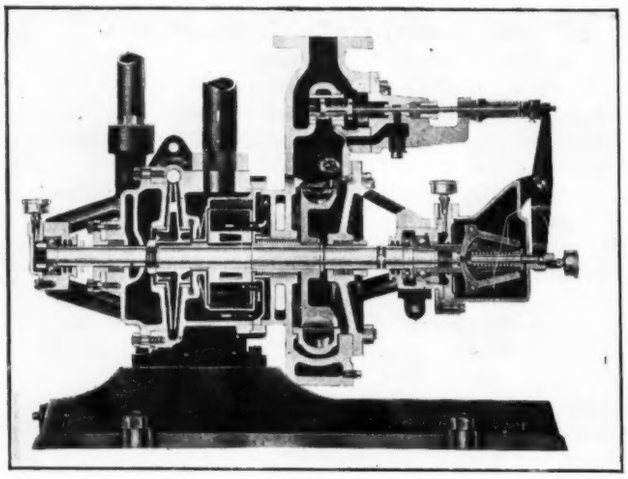


FIG. 1. SECTIONAL VIEW OF THE TURBINE, AIR AND CONDENSATE PUMPS

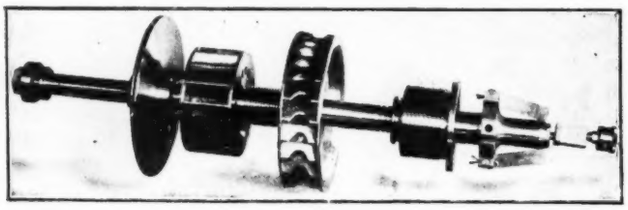


FIG. 2. THREE ROTORS ARE MOUNTED ON SHAFT

to the atmosphere. Also, the air is handled in a pump designed for air, and the water is handled in a pump designed for water.

The air end of the unit is a development of the Hytor vacuum pump, in which the rotor, the only moving part, revolves in an elliptical casing filled with water. The water turns with the rotor, but follows the casing, owing to centrifugal force. The water end of the machine is a centrifugal pump with an inclosed-type impeller designed to give high efficiency when handling hot water. It has the desirable characteristic of unloading when not handling condensation, and requires very little increased power when delivering against low heads. Provision has been made to vent the centrifugal inlet back to the receiving tank, which is under vacuum, so that air binding is impossible.

All interior parts of the pump are constructed of bronze with the exception of the steam-turbine rotor.

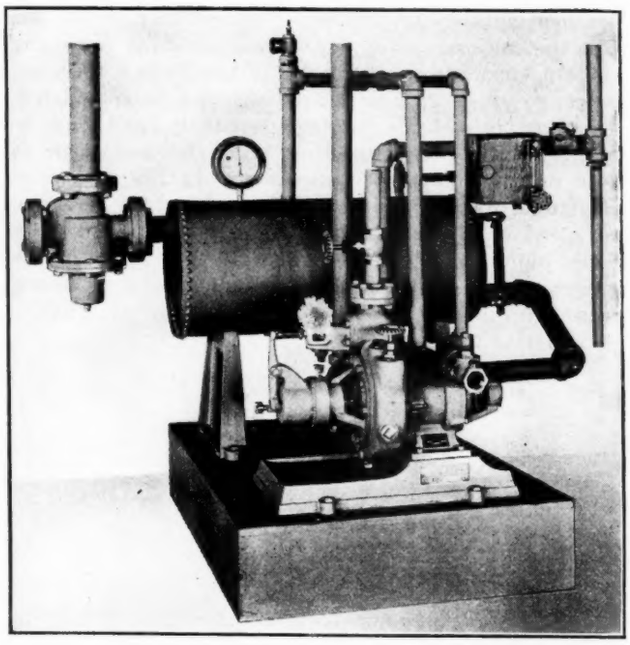


FIG. 3. PUMP AND RECEIVER CONNECTIONS

No lubricant is required in the interior of the pump, and no oil or grease can be introduced by the pump into the condensate.

The shaft upon which the impeller, rotor and steam-turbine wheel are mounted, is supported by annular ball bearings mounted outside of the casing in an adjustable housing. The steam-turbine rotating element consists of a solid steel forging with blades milled out of the rim. A centrifugal throttling governor maintains a constant turbine speed.

The turbines are designed to operate at 75 lb. steam pressure, although the turbine casing is suitable for steam pressures up to 200 lb. If it is desirable to work at pressures lower than 75 lb., satisfactory operation can be secured on pressures as low as 40 lb.

These pumps are built in sizes to care for up to 300,000 sq.ft. of equivalent direct radiation.

The procedure necessary in the operation of Diesel engines has been more or less shrouded in mystery. The average engineer has felt that success in the handling of the Diesel engine was possible by only those who possessed some mysterious talent. The same requisites are demanded in both the steam and oil-engine plants. The engineer must possess good judgment and have an appreciation of mechanical construction. With these in his possession along with some acquaintance with the principles of operation, there is no reason why any steam engineer should hesitate at the proposition of assuming charge of an internal-combustion engine plant.

Valves for Emergency Service

By W. H. WAKEMAN

TUBES in water-tube boilers fail because of one reason or another. Almost instantly the room is filled with hot water and steam, making it unsafe, if not impossible to go on top of the boiler and shut the stop valve. Unless provision has been made, the steam in all the boilers will blow out through the rupture, causing the entire plant to be shut down until the disabled boiler can be cut out and steam raised again.

If boilers were equipped with the type of valve illustrated in Fig. 1, the result would be different. The stem of the valve disc *A* slides in the seat *B*. So long as steam flows through the valve, as indicated by the arrows, the disc is raised, and affords a free passage. If the pressure in the boiler is reduced, thus reversing the direction of flow, the disc *A* is instantly forced to its seat and no more steam can pass back into the boiler. This valve action will automatically cut out a disabled boiler, and although the capacity of the plant would be reduced, the remaining boilers would prevent a complete shutdown of the plant.

This valve is fitted with a stem and handwheel, according to common practice, but it cannot be opened by hand as, for all practical purposes, it is a large check valve. When the wheel is turned from left to right as far as possible, the valve cannot open automatically. When turned from right to left, the disc *A* can rise, but only by the pressure under it. The wheel and stem may be used to regulate the lift of the disc *A*.

In a certain plant, which is typical of many others, the night gang cleaned the boilers, because some of them could be laid off then more conveniently than during the day run. When a boiler had been cleaned and filled to the proper level with cold water, in order to shorten the time necessary for raising steam, it was the custom to turn in live steam from the other boilers. While this heated the upper part of the shell and caused it to expand accordingly, it left the lower part cold for a time, hence the practice caused the boilers to be strained more than they would be by getting up the regular working pressure. This practice was not approved by the chief engineer, but as he did not hire and discharge the assistant engineers and firemen, he could not always control them. If each boiler had been fitted with a valve similar to that shown in Fig. 1, the men could not have carried on the practice, as the steam could not flow into the cold boiler, and when steam was raised to one or two pounds more than that in the header, the valve would open, thus automatically resuming the regular service.

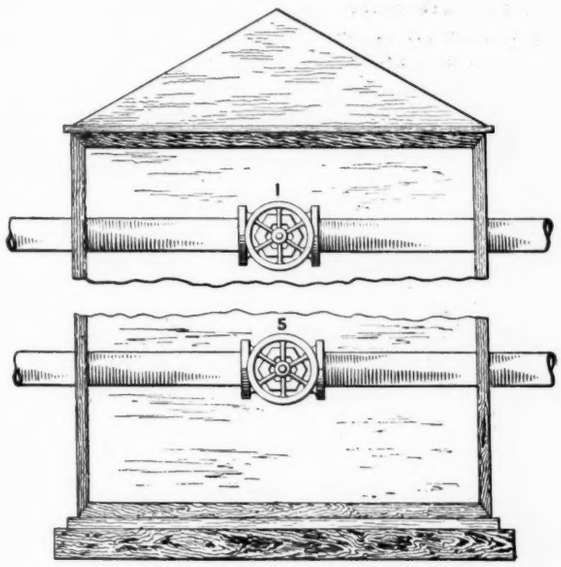


FIG. 4. FIVE-LINE VALVE CABINET

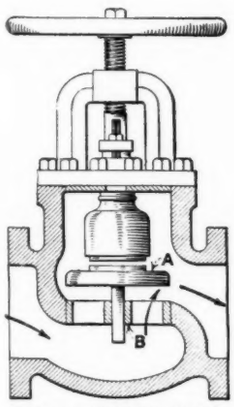


FIG. 1. SIMPLE NON-RETURN VALVE

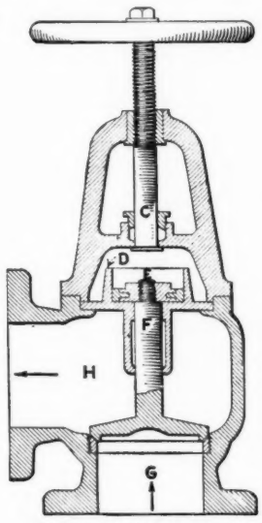


FIG. 2. ANOTHER NON-RETURN VALVE

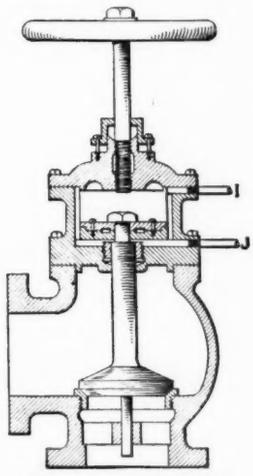


FIG. 3. PRESSURE-CLOSING VALVE

The valve shown by Fig. 2 is designed for the same general service, but is more elaborate. The stem *C* extends partly through the bonnet, but no farther. A dashpot is shown at *D*, in which the plunger *E* is operated by the action of the valve stem *F*. Steam must travel as indicated by the arrows, hence when the pressure is higher at *G* than at *H*, the valve is raised automatically. This valve prevents admitting live steam to a boiler after cleaning it. The water in the boiler must therefore be heated gradually by the fire until the temperature is nearly equal at all points. The dashpot is to prevent injury to the valve. Suppose that the valve stuck until the difference in pressure was 5 lb., and then was suddenly freed. If it was an 8-in. valve, it would be thrown upward with a force of 251 lb., if no provision had been made to counteract such a condition, but the dashpot prevents rapid movement of the valve, hence it is brought to rest quietly.

Fig. 3 is a more elaborate design, which may be used like either of the foregoing, but it is also designed

for still further service. When the wheel is turned back as far as it will go, as illustrated, the valve is free to operate as a check valve, but provision is made for closing it by direct boiler pressure. Suppose that a steam pipe bursts or the bonnet of a valve fails, or anything else occurs to cause a rush of steam from the header into the boiler room, while the valve which is on each boiler is wide open. A ½-in. valve, located in the engine room, is opened and instantly a stop valve on, say, No. 1 boiler is closed, because steam at full boiler pressure enters at *I* and forces the valve downward, thus shutting off the supply of steam. Stop valves on all boilers that discharge into this header are closed in the same way. The outlet *J* is provided to allow any steam that may leak past the piston, to escape freely to the outside air, so that it cannot act as back pressure on the valve and prevent quick action. This passage should always be open, hence a valve ought not to be on this pipe line, as it might be closed at the critical minute, thus eliminating the safety feature. This calls attention to the fact that safety appliances of various kinds are not always kept in good order, hence they are worse than useless, because they give the engineer an assurance of safety that is not warranted by real conditions.

Fig. 4 illustrates a cabinet with five valves to control five main stop valves similar to Fig. 3. These are numbered to correspond to the boilers. The latter ought always to be numbered from left to right, as we stand facing the fronts, the same as we read a printed page. Failure to observe this rule will cause more or less confusion.

The utility of this device may be further illustrated as follows: An engine or turbine may be in operation, when from some unforeseen cause the governor fails to control the speed, and an automatic stop motion was not included in the equipment. The throttle valve of an engine is almost always located in line with the flywheel, hence an attempt to close this valve under the condition stated is dangerous, but the valves shown in Fig. 4 can be opened and steam shut off without risk of further accident. Duplicate cabinets can be located in other rooms so that the engine could be shut down quickly in case of accident without notifying the engineer.

The valve stem in Fig. 5 is made in three separate parts. The lower part *K* is attached to the valve at the lower end and to a plunger in a dashpot at the upper. The middle section *L* is attached to a piston that is operated by direct boiler pressure. The upper part *M* is for the purpose of closing the valve by the handwheel shown. As the valve is shown closed, *K* is in its lowest position, but when the boiler pressure becomes about a pound higher than the header pressure, *K* is free to rise until it comes in contact with *L*, and this constitutes the regular running position. When steam is admitted through *N* to the chamber *O*, the piston below it is forced downward, thus instantly closing the main stop valve. As the piston in *O* is larger in diameter than the main stop valve, prompt action of the latter is insured.

While the device illustrated for operating the valve shown in Fig. 3 is a safeguard, it is not automatic, hence there is danger of delay in operating the cabinet valves in case of accident, and inasmuch as a few seconds of inaction at such a time may cause much trouble, an automatic device, from which the human element is eliminated, is more desirable.

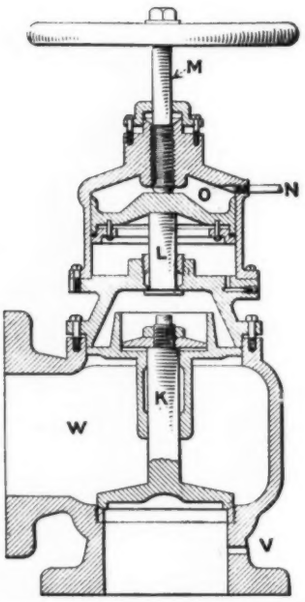


FIG. 5. PILOT-VALVE OPERATED NON-RETURN VALVE

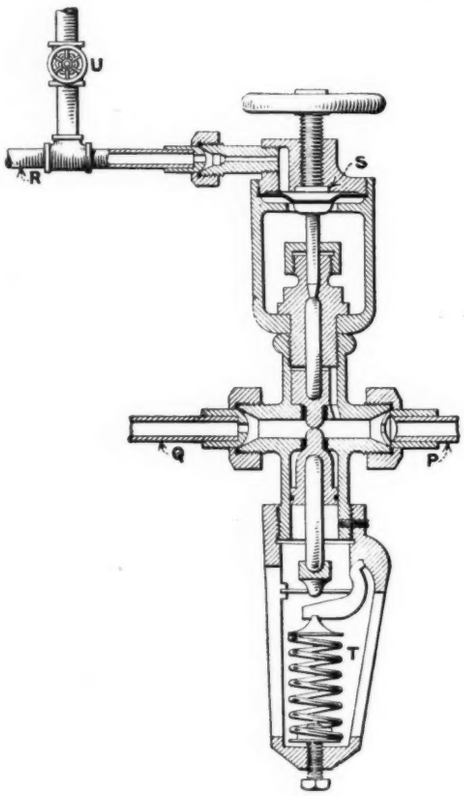


FIG. 6. PILOT VALVE USED WITH NON-RETURN VALVE

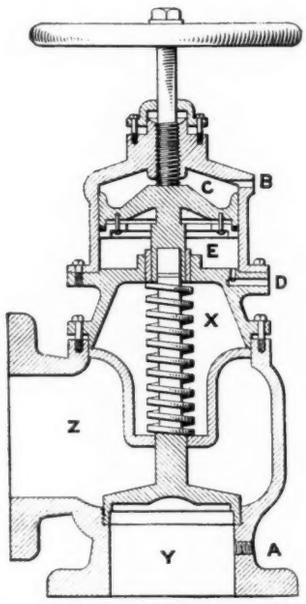


FIG. 7. ONE TYPE OF REDUCING VALVE

Such a valve is shown by Fig. 6. Steam under full boiler pressure is always effective at *P*, but it cannot pass out of *Q* because a valve between them is closed under normal conditions. Steam from the outlet *V* in Fig. 5 is delivered by suitable piping into *R*, Fig. 6, and as this pressure acts on the diaphragm *S* it keeps the valve closed between *P* and *Q*. If an accident allows steam to rush out of *W*, Fig. 5, it will cause a reduction of pressure at *V*, also at *R*, Fig. 6. As this reduces the holding power of *S*, it allows the coil spring *T* to open the valve, and steam instantly goes out of *Q* and, entering through *N* into *O*, Fig. 5, closes the main stop valve. By means of the valve *U*, Fig. 6, it is possible to test the apparatus and ascertain its exact condition. When this valve is opened, it allows steam to escape to the atmosphere, which reduces the pressure in *R*, thus causing the device to shut the main stop valve, the same as if an accident had caused the reduction of pressure.

In some plants it is customary to reduce the boiler pressure for special conditions. A valve that is designed for such service is illustrated in Fig. 7. Suppose that the boiler pressure is 120 lb., and 90 lb. is wanted on one of the lines leading from the header, a difference of 30 lb. The spiral spring *X* is designed to resist a pressure of 30 lb. per sq.in. on the face of the valve. In other words, when there is 120 lb. in *Y*, there will be 90 lb. pressure in *Z*. If the boiler pressure changes, the comparative difference will be maintained.

As this condition is not found in every plant, an explanation of the utility of this valve is given as follows: One engine or turbine in a plant is heavily loaded, so that it is necessary to carry a high pressure to secure satisfactory operation. Another engine has but a light load, and it is well known that some engines are noisy and unsatisfactory under a light load. By reducing the pressure on the line that supplies this engine, it will run quietly with better results generally.

In other cases steam at low pressure may be satisfactory for a certain process, but it must be dry. Steam may come to the valve at high pressure, but containing more or less moisture. Of course there is just as much heat in the steam after it passes through this valve as there was before, although the pressure is lower, hence this extra heat will be utilized in evaporating moisture in the steam, leaving it dry.

The automatic device shown in Fig. 6 can be applied to the valve shown in Fig. 7 as follows: Full boiler pressure is always on at *P*, Fig. 6, and the pipe *R* is connected to *A*, Fig. 7. If a sudden rush of steam through *Y* causes a reduction of pressure, it will also be reduced in *A* and thence in *R*, Fig. 6, consequently steam is sent through *Q*, Fig. 6, to *B* in Fig. 7, and as the chamber *C* is then under boiler pressure, the piston below it is forced downward and the valve is quickly closed. An outlet is provided at *D* to allow steam that may have leaked by the piston, to escape to the atmosphere. This passage must never be closed, for if it is, pressure may accumulate in *E* and prevent the valve from operating quickly.

However, in this connection attention is called to the fact that *C* does not maintain a constant reduced pressure, as in the case of an ordinary reducing valve, but gives a difference of 30 lb. (or any other for which it may be designed) between the boiler pressure and the lower pressure delivered. This valve may be closed by hand by the wheel shown, but it cannot be opened in the same way.

Fig. 8 illustrates another valve that is partly automatic and that may be closed from a distant station in case of accident. It is shown open, so that steam is passing upward, but if a tube in the boiler should burst or collapse, the flow of steam would be reversed, hence the valve would close, as the stem is free to slide in the guide provided for it. The piston on the upper end of this stem is designed to operate the valve as follows: Steam direct from the boiler, or from any other source where full pressure is carried, is delivered to *F* and, passing through the pipe to the left, enters the cham-

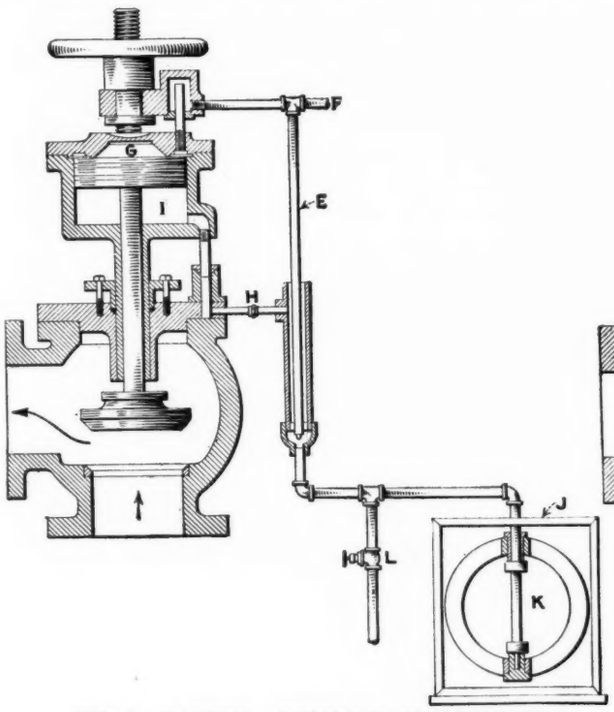


FIG. 8. PARTLY AUTOMATIC NON-RETURN VALVE

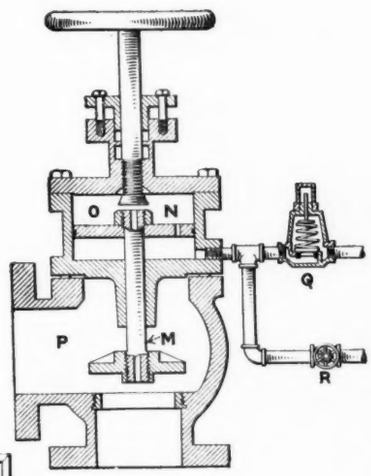


FIG. 9. HAS THREE FUNCTIONS

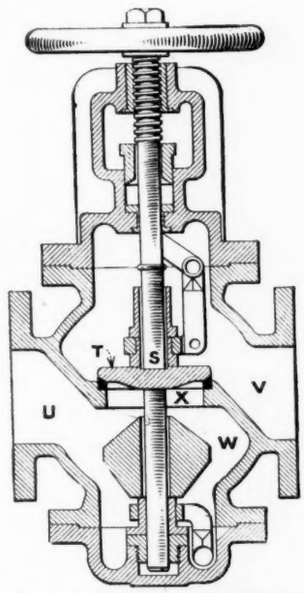


FIG. 10. OPERATES IN EITHER DIRECTION

ber *G*. It also passes down through *E* and *H* to the lower chamber *I*. As the pressures in *G* and *I* are equal, the piston is free to act as if there were no pressure at all on it. The steam pipe is continued until it enters the square cabinet *J*, which may be located at any convenient place. A gage glass is shown at *K* without an outlet, as none is needed.

Suppose that an accident happens, making it necessary to close the valve to prevent the escape of steam into the boiler room: When a fireman discovers this state of affairs, he seizes a piece of pipe or any convenient weapon and breaks the glass *K*, which liberates a small volume of steam. The pressure is maintained in *F* and *G* and also in *E*, but as it continues downward through the orifice shown, steam is drawn out of *I*, hence the pressure in *G* forces the valve downward. The device may be tested at any time without breaking the glass, by opening the valve *L* to cause a circulation of steam.

Automatic Three-Function Valve

Fig. 9 illustrates another automatic valve which will perform three duties under different conditions. It will prevent steam from flowing back into the boiler. If there is an abnormal rush of steam from the boiler, causing a reduction of pressure in the pipe, it will close. It can also be used as an ordinary stop valve that is closed by hand, and the stem can be packed under full pressure, when the wheel is turned to the left to the limit.

In regular service steam moves upward through the valve body and out at the left. The valve must be installed with the stem in a vertical position. The lower portion of the stem *M* is hollow, therefore steam passes up through it into the cylinder *N*, where it acts on the face of the piston *O*, which is more than twice as large as the valve disc *P*. A hole is drilled through *O*, but it is smaller than the passage through *M*, hence steam can always be delivered into *N* faster than it escapes, thus maintaining pressure at this point, although circulation is permitted.

The pilot valve *Q* must be installed as shown, with a tee between it and the main valve. The outlet from *Q* must be connected to the pipe line that is supplied with steam through the main valve. The pilot valve may be adjusted to open at any desired pressure less than the boiler pressure. Suppose that it is set to open at 10 lb. less. An abnormal rush of steam caused by a broken pipe, a ruptured flange or a runaway engine, causes a reduction of 10 lb. The valve *Q* opens and allows steam to pass through it to the pipe line. This causes a reduction of pressure under *O*, consequently it is forced downward and the main supply of steam is shut off by *P*. The valve *R* is provided for the purpose of testing the device. By opening it, steam is allowed to blow out and reduce the pressure under *O* to the same point as if *Q* was opened because of an accident.

The valve, Fig. 10, is self-contained, although it operates automatically in either direction. The handwheel is shown turned to the right hand as far as it will go, thus positively closing the valve, but the stem terminates at *S* and acts as a guide to the valve *T*. When *S* is raised by turning the handwheel toward the left, *T* is free to rise as the current of steam passes from *U* to *V*. If an accident at the boiler end reverses the flow of steam, *T* closes instantly.

On the other hand, if an accident at the engine end causes an abnormal flow of steam, the valve *W* is raised by it until it strikes the seat *X* and closes the valve. Both *T* and *W* are fitted with links and levers that can be operated by hand from outside of the casing, thus showing the condition of the valves at all times.

When a plant is fitted with modern devices to insure safety and economy, it requires more intelligent attention than the old-fashioned plain plant demands, but the time thus spent is amply repaid in better results secured. The chief engineer of today must have different qualifications from his prototype of an earlier period.

A Pressure Indicator for Internal Combustion Engines

By J. Okill, M.Inst.A.E.*

It will be admitted that even in the best-equipped engine-testing departments of the various works and research laboratories, where information is sought for with regard to the working of high-speed internal-combustion engines, many valuable data cannot be obtained owing to the slow development of suitable testing instruments.

The truth of this statement is supported by the almost entire absence of indicator diagrams from the numerous papers that have been written dealing with experimental work carried out with high-speed petrol

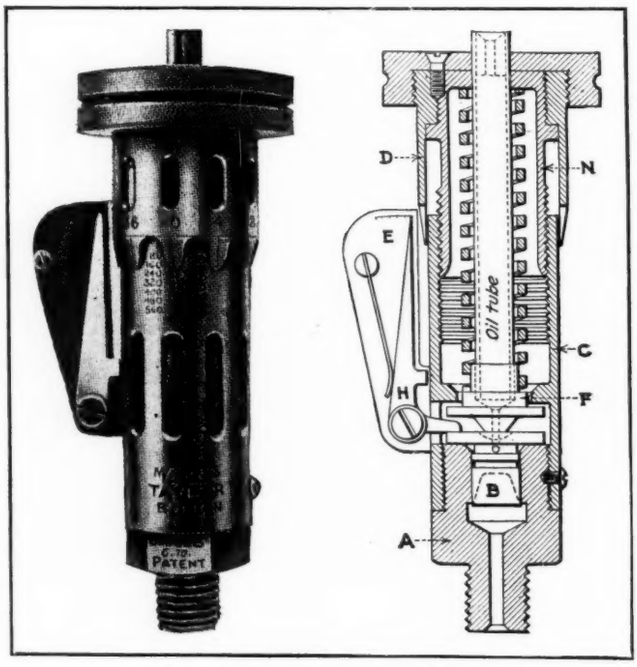


FIG. 1. PRESSURE INDICATOR

engines. From this it is evident that diagram indicators are not practical propositions from the high-speed engine builders' point of view. The value of the modified form of steam-engine indicator as an indispensable aid to the internal-combustion engine tester and research workers cannot be overestimated, but, as is well known, its use is limited to what one may call moderate engine needs.

*Engineering Faculty, University of Liverpool.

The mechanism of an indicator is subjected to more severe treatment from engines operating on the "Otto," or constant-volume, cycle than when subjected to the gradual pressure changes common to engines operating on the Diesel, or constant-pressure, cycle. In the Otto cycle the rapid acceleration of the indicator piston and its attached mechanism, due to the constant volume combustion and instantaneous rise in pressure from that

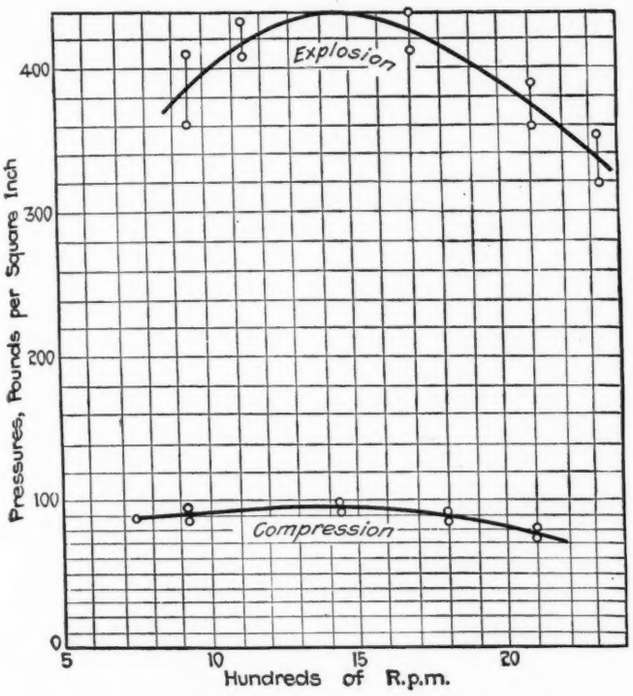


FIG. 2. PRESSURE READINGS FROM A FOUR-CYLINDER ENGINE

of compression to maximum explosion pressure, introduces inertia effects whose value cannot be determined.

These inertia effects, combined with the inertia of the oscillating drum on which the paper is mounted, together with the elasticity and lag of the drum-operating mechanism, discount the value of the resulting diagram. The use of strong springs and small-diameter drums enables diagrams to be taken from comparatively high-speed engines, but as the diagrams so obtained are of small size, correct determinations of mean effective pressures are doubtful, and perhaps what is of more importance, valuable features relating to combustion, which would be prominent on a large diagram, are masked on the smaller one.

The writer would put the speed at which pencil-lever diagram indicators cease to be useful at approximately 600 r.p.m., although it is impossible to say at what lower speeds the mean effective pressure as measured from the diagram is in error.

It is true that the optical type of indicator enables diagrams to be obtained from engines running at the highest speeds, as in this indicator inertia effects are reduced to a minimum. However, optical indicators require very careful manipulation and adjustment, while the difficulties encountered in attaching them to multi-cylinder engines with inclosed crankcases are such as to render their application unpopular.

When one visualizes the complex actions that take place during each cycle in the operation of a high-speed petrol engine, it will be admitted that if the compression and ignition pressures can be measured at any engine speed, useful deductions and corrections may be made, that will improve the running and fuel economy of the engine. Requiring a device for the purpose of high-speed engine testing, the writer set himself to design an instrument that would measure these pressures quickly and accurately and without delicate operating gear likely to be deranged in continuous and rapid use. The most important considerations in the design were the complete elimination of inertia effects and a minimum increase in clearance volume. These features were embodied in a comparatively simple instrument shown in Fig. 1. The principal part of the indicator comprises a small cylinder *A* with its piston *B*, these being in communication with the combustion chamber of the engine cylinder. The piston is forced upward by the pressure of gas underneath it, this upward pressure being balanced by an adjustable coiled spring pressing downward on the piston. When the spring is insufficiently compressed, the piston is lifted a limited amount by the pulsating pressure in the engine cylinder; but when correct adjustment is obtained, the piston just fails to lift under the momentary maximum pressure occurring at the end of compression and the telltale *H* remains stationary.

The upper support for the coil spring is formed by the inner sleeve *N*, and by screwing down this sleeve into the barrel, the pressure of the spring on the piston may be regulated to any desired amount and is read directly from the pressure graduation on the barrel *C*.

The spring is adjusted until the movement of the piston (and finger) just ceases; that is, when the maximum pressure of the gas is exactly balanced by the downward pressure of the spring.

Curves giving compression and maximum explosion pressures in the cylinders of a four-cylinder poppet-valve engine are plotted in Fig. 2. At 740 r.p.m. the compression pressures are exactly the same in each cylinder, while at the higher speeds the variation between one cylinder and another is not more than about 5 lb. per square inch. The reduction in mass charge to the cylinders at 2,100 r.p.m. is clearly defined. The short vertical line joining the high and low points is a measure of the explosion pressure variation in the four cylinders, at each of the observed speeds.

Useful information is obtained by taking pressures in the exhaust manifold; also by motoring the engine with and without its carburetor, and noting the effect of carburetor resistance on compression pressure. For measuring the fuel-oil injection pressure in solid-injection Diesel and semi-Diesel engines, the instrument is eminently suitable, while owing to its extremely small clearance volume, it is useful for measuring the maximum pressures in the cylinders of high-speed air compressors.

As an adjunct to the pencil-level or optical types of indicator, it is of service as a means of verifying the pressure scale of these instruments under running conditions.

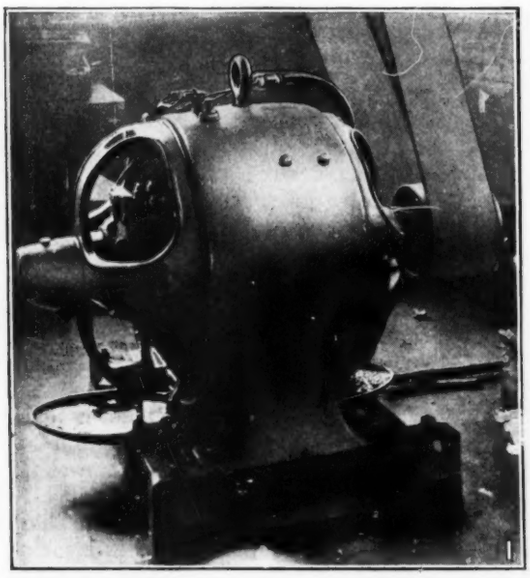
If necessary, calibration of the indicator can be readily made by the aid of a fluid pressure dead weight gage tester, or other suitable gage-testing machine using this oil. To do this, connect the indicator to the gage tester in the ordinary manner, then apply the test pressure and adjust the indicator spring pressure until the telltale just comes to its zero position.

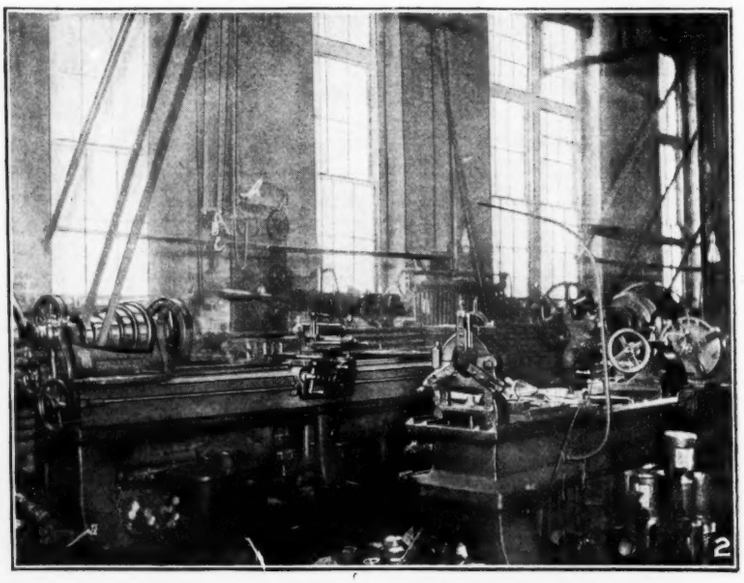
POWER PLANT MACHINE SHOPS

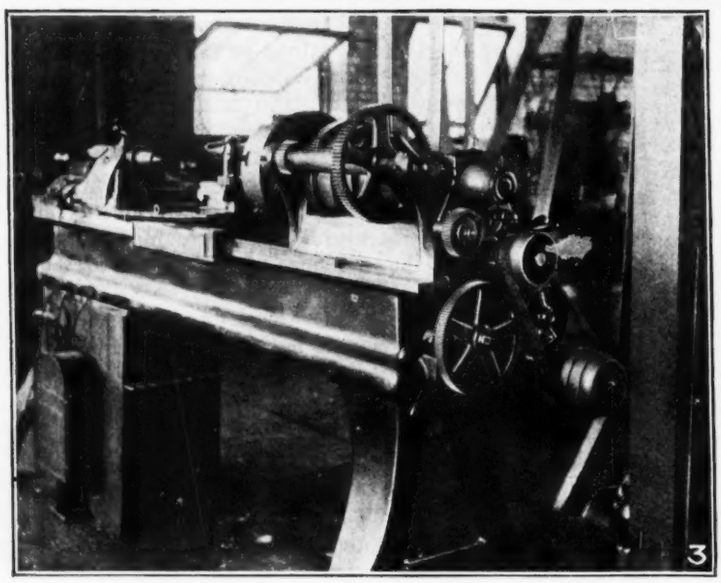
By W. O. ROGERS

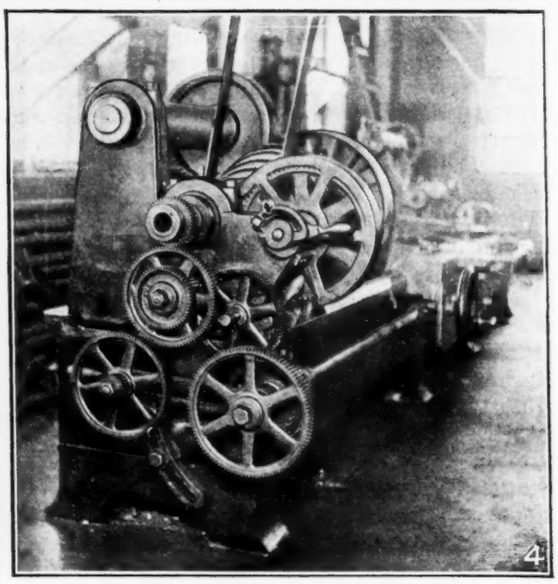
MOST large modern power plants operate a more or less complete machine shop, in which general and emergency repairs are made by the plant mechanics, thus obviating the necessity of sending the work to some outside shop. There is generally sufficient repair work about a power plant to justify the employment of two or three or more mechanics, and although there may not be emergency work to be done every day, there is sufficient regular work, such as making up parts that habitually require renewing and other routine work, to keep the men employed.

The number and size of the shop tools depend upon the demands of the plant. For the average power plant one large and one small engine lathe, a shaper, a planer, a large and a small drill press, a milling machine and an emery stone will meet the ordinary requirements. A welding apparatus will be found of value for repairing broken castings, etc. These machines may









FIGS. 1 TO 4. MOTOR AND TYPES OF ENGINE LATHES FOR POWER-PLANT MACHINE SHOPS
Fig. 1—Direct-current motor for group drive. Figs. 2, 3 and 4—Types of engine lathes.

be driven by separate motors or by one large motor (see Fig. 1) driving a lineshaft from which the various machines are belt-driven. The individual drive is generally the most efficient, as each motor can be shut down as soon as the operator is through using the machine. With the group drive the one motor is in operation as long as any one of the several machines is being used, hence a comparatively large motor is used by a machine requiring but a fraction of the motor capacity. There is, therefore, an initial loss at the motor to which is added the friction of the belt and of the shafting bearings.

The group arrangement of motor drive can be simplified by driving two or more lineshafts by as many small motors, belting from the shaft to such machines as will be most constantly in use, as for instance, a small drill press, lathe and an emery stone from one motor and shaft. Another shaft and motor can be belted to drive a large drill press and shaper, or another motor and its lineshaft belted to drive a large lathe and perhaps a planer. The general arrangement of such drives will be determined by the demand to be made on the various machines and the amount of money available for installing the machine-shop tools and apparatus.

In making visits to various power-plant machine shops some up-to-date apparatus was found, enabling practically all the repair work necessary to keep a power plant in operating condition to be done at the plant. Each shop had two or more engine lathes, one of small size, or from 10 to 14 in. swing, for general work, and a large lathe of around 24 in. swing for heavier service. Some large lathes used were of from 44 to 48 in. swing and capable of carrying a shaft 36 ft. long between centers. These particular lathes were employed primarily for turning out piston rings, some of which were 49 in. in diameter. In order to handle work of this size, it was necessary to raise the head and tailstock on the lathe by putting a distance block, Fig. 5, between them and the lathe bed. Fig. 2. Figs. 3 and 4 show lathes suitable for plant work.

Frequently, the motor selected to supply power for driving a machine shop is used because it happens to be handy, or it may be the only one available without purchasing a new one. It may or may not be suitable either in design or in capacity. Certain machines require, if the most economical results are to be obtained, a certain type and size of motor. Shunt-wound motors are adaptable for driving machine groups and lineshaft drives and also tools that require considerable speed adjustment, such as lathes, boring mills, etc. Compound-wound motors are adaptable for use on machines that are subject to sudden demand for excessive power of short duration, as for instance, planers. Series motors are preferable when the speed regulation is not important and where an excessive torque and slow starting speeds are required, such as moving the carriages of large lathes and raising and lowering the cross-rail of planers and boring mill, crane operation, etc. It is not advisable to use a series motor when the motor can be run without loads, as the speed would accelerate beyond the safety limit. The aforementioned motors are of the direct-current type.

Alternating-current motors are also used for driving machine tools. What is termed the squirrel-cage motor corresponds to the constant-speed shunt-wound direct-current motor, but with a rotor of high resistance it approaches more closely the characteristics of the compound-wound direct-current motor. It is used on boring mills, radial drills, drill presses, grinders, lathes, milling machines, planers and screw machines.

Motors that are designed for machine-shop tool drives are generally made in about ten standard sizes as being sufficient for practically all requirements of machine tools. These are 1 and 1½-hp. in direct current only, and 2, 3, 5, 7½, 10, 15, 20 and 25 hp. for both direct and alternating current. The voltage used for direct-current motors is 115 and 230 and for alternating-current motors 110 and 220 volts.

The power required by a lathe for cutting is determined by the power that can be imparted to the machine

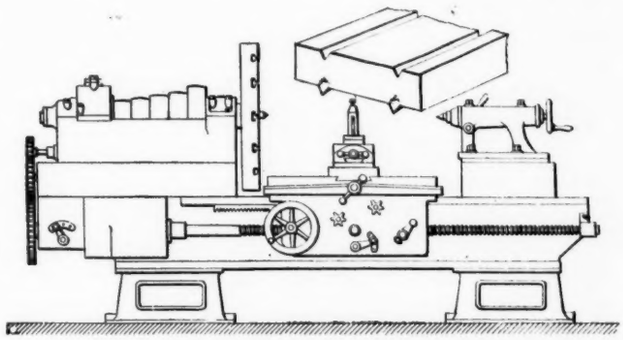


FIG. 5. DISTANCE BLOCKS TO GIVE LATHE GREATER SWING

by means of the cone pulley, if belt-driven. The table shows the motor sizes for various engine lathes.

MOTOR HORSEPOWER FOR ENGINE LATHES*

Swing, Inches	Average	Heavy
12	¼	2
14	½–1	2–3
16	1–2	2–3
18	2–3	3–5
20–22	3	7½–10
24–27	5	7½–10
30	5–7½	7½–10
32–36	7½–10	10–15
38–42	10–15	15–20
48–54	15–20	20–25
60–84	20–25	25–30

*Recommended by the Westinghouse Electric and Mfg. Co.

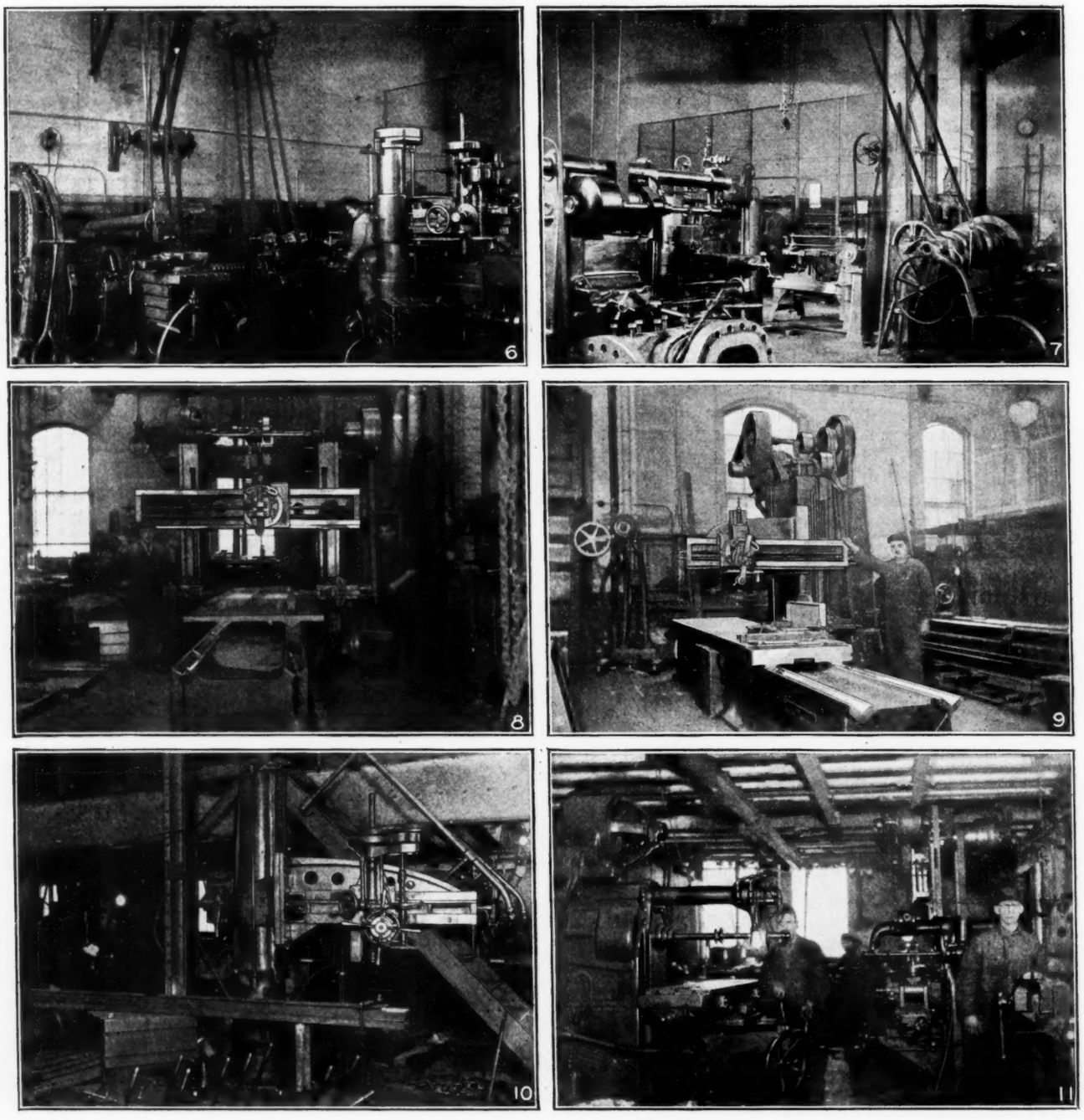
The power required to start a lathe is often greater than that needed to do the cutting operation. A motor used with an individual lathe must be large enough, and its horsepower rating may be larger than required for the mere cutting operation. With group drive the chances are that not all the tools will be started at the same time, therefore the horsepower of the motor need not be so large as that required by the total rating of the various tools.

With group drives the motor may be of the high-speed constant-speed type, the speed changes being made by the cone pulley and belt shifting. This would require a motor of comparatively small dimensions, and for direct-current the ordinary shunt-wound motor is used; for alternating current the ordinary squirrel-cage induction motor is used.

When using induction motors, a wound-rotor type may be directly geared or belted to the machine tool, or a constant-speed motor may be belted to the tool. For direct current the semi-inclosed interpole shunt-wound adjustable-speed motor is commonly used, employing the field method of control. This type of motor offers wide speed variations and good torque characteristics. If the speed changes are to be made by means of the cone pulley and belt shifting, or by other mechanical means; an alternating-current motor or a direct-

current motor may be used. The use of an induction motor ordinarily implies constant speed of a unit. A constant-speed shunt motor may be equipped with field controls, frequently attached to the lathe, which allow a small margin of speed adjustment.

Motors used for driving machine tools may be located as convenience dictates. Modern tools have them mounted on the machine, as shown at the base of the boring mill and the drill press at the right in Fig. 6. It may also be placed on the floor, as shown at the left in the same illustration, or secured to a support attached to the wall, as shown by the belt driving the shaper at the extreme left of the illustration. The two first mentioned machines are directly connected to the motor through reducing gears. The lathe motor is belted to a short countershaft carrying a cone pulley, which in turn is belted to the cone pulley of the lathe. A similar idea is carried out in driving the shaper, with the exception that the motor is placed above the machine and is belted to the machine through a countershaft, hung from the side wall. The same idea is carried out in the motor drive of the machine shown in Fig. 7; even the emery stone is so driven, also the hacksaw, the motor for each being supported by the column shown.



FIGS. 6 TO 11. MACHINE TOOLS FOUND IN USE IN POWER-PLANT MACHINE SHOPS

Fig. 6—Machine tools direct and belt motor driven. Fig. 7—Induction motor belt-driven machine. Fig. 8—A 12-ft. motor-driven planer. Fig. 9—14-ft. planer driven by a 15-hp. induction motor. Fig. 10—Motor-driven radial drill. Fig. 11—Two motor-driven milling machines.

The two-spindle boring mill, Fig. 13, is used in a plant machine shop where all other machines are driven by the 20-hp. direct-current motor shown in Fig. 1. This shop is an example of the single motor drive. The

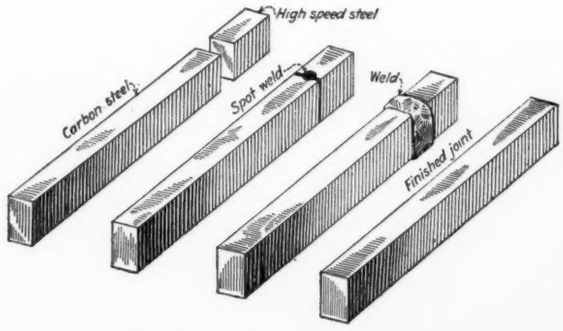


FIG. 12. STAGES OF WELDING MACHINE TOOLS

motor is run continuously throughout the day regardless of whether the entire equipment is used or only the power-driven hacksaw. This motor drives one 14-in. swing engine lathe, one 44-in. swing lathe, one shaper

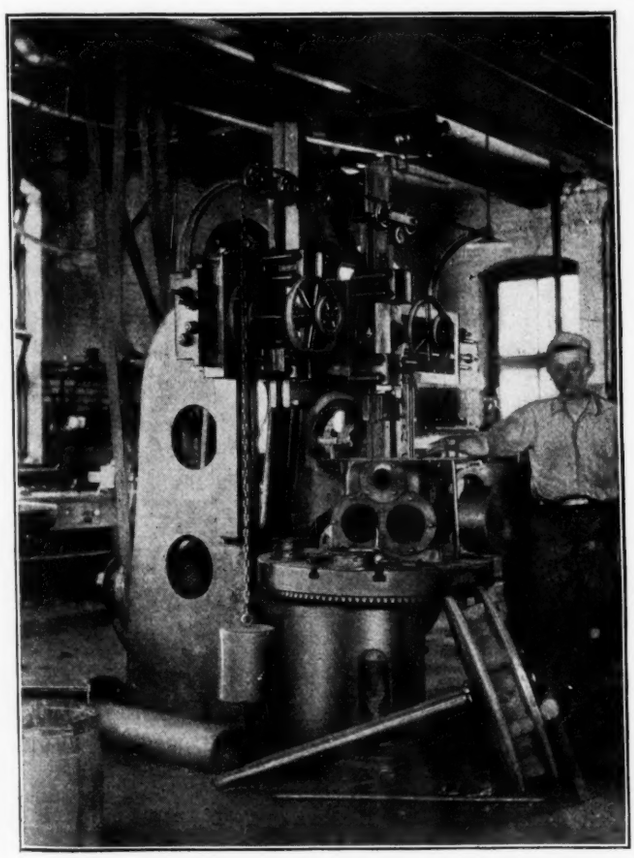


FIG. 13. BELT-DRIVEN TWO-SPINDLE BORING MILL

of 28-in. stroke, one two-spindle boring mill, one small drill press, one large upright drill press, one power hacksaw and an emery wheel. During the writer's visit to this plant, at times nothing but the small hacksaw was in use, requiring not much more than one horsepower to operate it. Occasionally, the small drill press was used for drilling one or two holes, a matter of a few moments' time. The total load on the motor, which would include the main shaft and countershaft, belt and friction, and the power used by such machines as were running, would probably be around 7 hp., whereas if individual drives had been utilized the power requirements would not have exceeded 2 hp. The efficiency of

FIG. 14. BELT-DRIVEN SHAPER

the motor would, with a small load, be reduced from, say, 80 per cent at 20-hp. output, or full load, to about 65 per cent efficiency at, say, one-third load at 7 hp., as is assumed as being developed.

Electrical energy is supplied to the plant's machine shop cheaper than it is sold to outside shops, but it costs money to generate it and the same amount of coal is used to generate a kilowatt-hour of current (costing the company, say one cent) as is used to generate a kilowatt-hour that will sell for 6 to 10 cents, a loss of 5½ cents per kilowatt at the cheaper rate.

Planers are handy tools to have in the power-plant machine shop and are generally used to produce flat

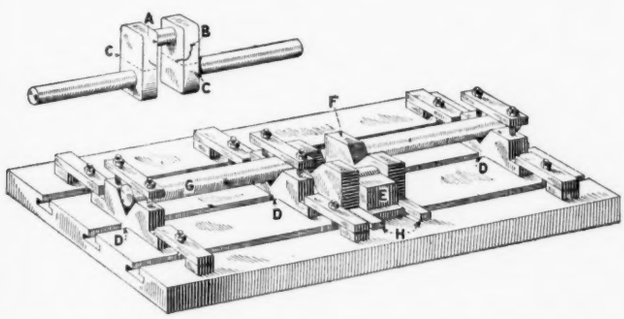


FIG. 15. READY TO WELD A BROKEN CRANK SHAFT

surfaces. Figs. 8 and 9 are views of two planers found in one machine shop, both motor-driven. The one shown in Fig. 8 has a 12-ft. by 54-in. bed and is driven by a 26-hp. induction motor by means of gears and cross-shafts across the top of the machine, the reversal of the bed being by means of a shipper and belt. The planer shown in Fig. 9 has a 14-ft. by 42-in. bed and is driven by a 15-hp. induction motor. This machine is used for lighter work than the other.

Planers are usually equipped with compound-wound direct-current motors or with alternating-current induction motors. The horsepower of the motor in either

case is the same for the given size of machine. A planer 22 in. wide requires a 3-hp. motor; one 24 to 27 in. wide, 3-5 hp.; 30 in., 5-7½ hp.; 36 in., 10-15 hp.; 42 in., 15-20 hp.; 48 in., 15-20 hp.; 54-60 in., 20-25 hp.; 72 in., 25-30 hp.; 84 in., 30 horsepower. Drill presses should, if motor-driven, be equipped with a variable-speed type of motor that may be direct-connected to the machine itself or arranged to drive the machine countershaft. Drilling machines are made in various designs and sizes and are intended for drilling holes with flat, twist or other kinds of drills, for counterboring, reaming and general boring operation. This also applies to the radial drill, Fig. 10. The power required for various sizes of drills and boring machines driven by either adjustable-speed shunt-wound direct-current, constant speed shunt-wound direct-current, or alternating-current squirrel-cage induction motors, varies with the size of the units. Sensitive drills up to ½-in. will operate with a ¼-¾ hp. motor; upright drills 12-20 in. size, 1 hp.; 24-28 in., 2 hp.; 30-32 in., 3 hp.; 36-40 in., 5 hp.; 50-60 in., 5-7½ horsepower.

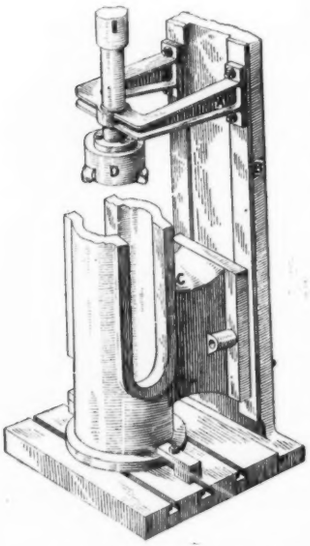


FIG. 16. BORING ENGINE GUIDES ON A DRILL PRESS

The sizes of radial drills are designated by the length of the arm in feet or in inches. A 4-ft. radial drill requires a 3-hp. motor; 5- and 6-ft. radial drills, a 5-hp. motor; 8-, 9- and 10-ft. machines, 5-7½ horsepower.

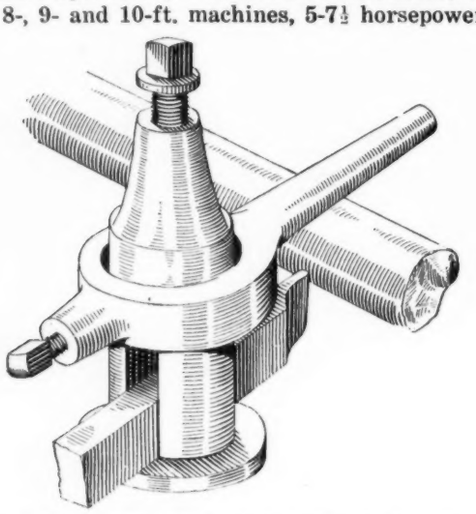


FIG. 17. STRAIGHT-TAIL DOG PREVENTS CHATTERING

Shapers, Fig. 14, might be called miniature planers, one difference being that instead of the tool remaining stationary and the piece of work moving back and forth with the bed, the work is stationary and the shaper head and the tool move back and forth, the cutting taking place as on the forward stroke of the shaper ram. This machine is used for miscellaneous work, such as facing, surfacing, notching, keyseating and for producing flat surfaces of all kinds on small work. It is well adapted for handling special and unusual work within its capacity. The power to drive shapers of various sizes is as follows: One with a 12-16 in. stroke requires a 2-hp. motor; 18 in. stroke, 2-3 hp.; 20-24 in. stroke, 3-5 hp.; 30-36 in., 5-7½ horsepower. The cutting speeds employed are usually up to 50 ft. per minute with feeds ranging from 0.005 to ⅜ in.

Milling machines, Fig. 11, are used for a large variety of work. Different shapes may be machined by using various form cutters, and with wide-spaced

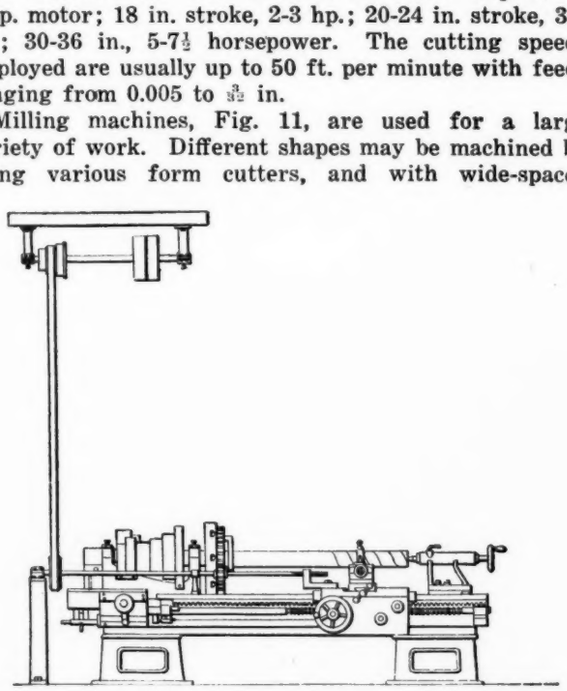


FIG. 18. RIG FOR CUTTING THREADS OF GREATER PITCH THAN CHANGE GEARS WILL PERMIT

toothed cutters flat surfaces are economically produced. The sizes of motors for milling machines are as follows: With a table feed of 24 in. and a cross-feed of 8 in. a 3 hp. motor is required. A 30-in. table feed, 10 in. cross-feed, 5-7½ hp.; 36-in. table feed, cross-feed 12 in., 7½-10 hp.; 50-in. table feed, 12 in. cross-feed, 10-15 hp. These are for horizontal machines, plain and of the universal types.

The foregoing motor horsepowers are the recommendation of the Westinghouse Electric & Manufacturing Co.

A lubricant of some sort is desirable for cutting tools used for turning, drilling, boring, reaming and thread-

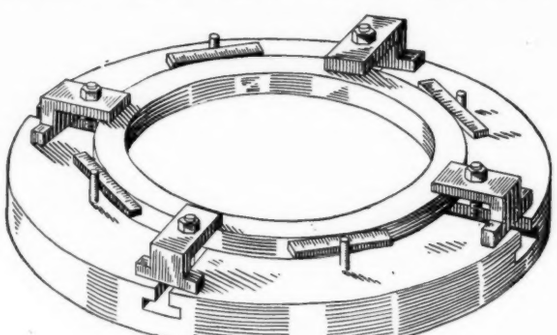


FIG. 19. CENTERING WORK ON TABLE OF VERTICAL BORING MILL

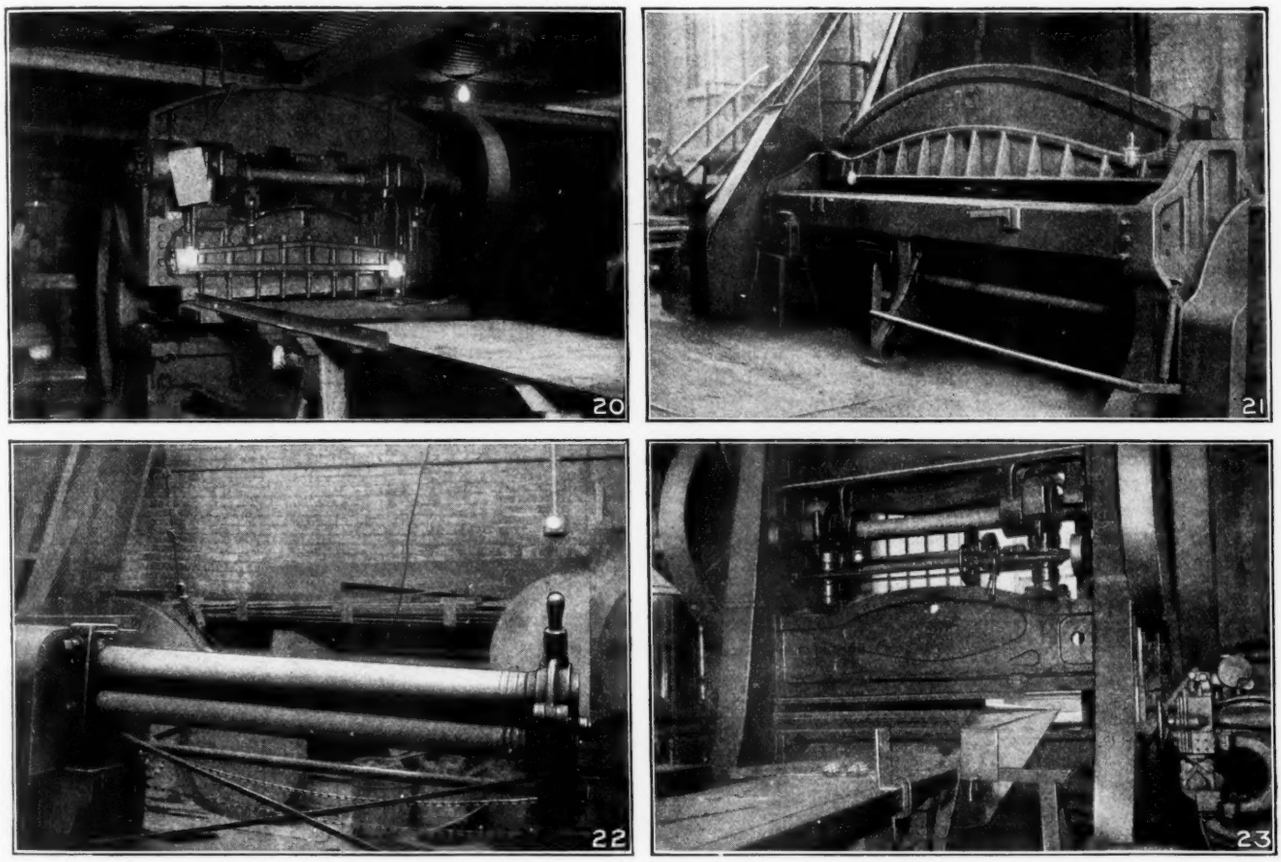
ing. Lard-oil compounds are extensively used. A good oil mixture of about 78 per cent of lard oil (a very good engine oil) and 22 per cent No. 1 pure lard oil, is especially good for all grades of steel, including hard and tough alloys. For work that does not require a fine finish a lubricant compounded of about 93 per cent

of mineral oil and 7 per cent of No. 1 lard oil is suitable. Another mixture is made as follows: For general work, a compound of ½ mineral lard oil, ¼ paraffin and ¼ kerosene gives good results. One for steel is 3½ gal. of water, ½ gal. of mineral lard oil and ½ lb. borax. For roughing on steel, 5 gal. water, ½ gal. good mineral oil and ¼ lb. soda ash. For drilling and milling, ½ gal. soluble cutting oil, 14½ gal. water. For screw-cutting on engine lathes, 60 per cent lard oil and 40 per cent mineral oil. Kerosene is frequently used for brass. The amount of oil used depends on the nature of the work and the material to be cut and is largely a matter for the operator to decide, but most operators favor flooding both work and tool.

One method of keeping down the cost of lathe and planer tools is to use a shank made of carbon steel, to which is oxyacetylene-welded a cutting tool of high-speed steel. A soft shank avoids tool breakage and the high-speed cutting end can be replaced at low cost. The steel tip may be butt-welded to the carbon-steel shank. The electrical energy required is from four to ten volts and from 400 to 500 amperes, depending on the section of the tool to be welded. The carbon-steel shank and the high-speed steel tips are cut to length. For a straight tool the tip is about 3 in. long, but for a bent tool is about 1½ in. longer. A spot weld, Fig. 12, over the joint of the two sections holds them in adjustment. The tool is then placed in the jaws of the butt welder and is united in approximately one-half minute. Tools may also be tipped by use of the arc welding apparatus.

Welding was doubtless given more prominence during the period of the war than ever before, and especially in connection with the work carried on in repairing the machinery of the German ships that were damaged by their crews while tied up at various American seaports. As a result of the good work done in making these repairs and the recognized value of the welding process, many power-plant machine shops are equipped with welding outfits.

In one instance a crank *A*, Fig. 15, of a small center-crank engine was fractured at *B*. The web was cut along the line *CC* and a new pin made to replace the old one, so as to save the time necessary for turning a new pin after it had been welded in place. The new crankpin was made $\frac{1}{16}$ in. oversize so that there would be enough stock for turning in case the part moved while welding. If the weld was made in alignment, it would then only be necessary to rebore the crankpin brasses to fit the pin. To keep the pin in proper alignment with the two crankshaft ends, four V-blocks were made with projecting lugs *D*, which fitted the groove in a planer table. Another block *E* of the same size was made without a lug. The ends of the webs were scarfed at an angle as indicated at *F*, and the parts were assembled on the planer table, the shaft *G* being secured in place in the V-blocks first, then the part containing the new pin and lastly, the other section of the crankshaft. After all were carefully aligned, the two strips *H* were secured to the table to act as a guide for the V-block in which the new crankpin rested, so as



FIGS. 20 TO 23. MOTOR-DRIVEN SHEARS, ROLLS AND METAL-BENDING MACHINE
Figs. 20 and 21—Motor-driven plate shears. Fig. 22—Motor-driven bending rolls.
Fig. 23—Bending machine driven by a motor and belt.

to permit the pin to expand when heat was applied. To take care of this expansion, the distance between the center of the pin to the center of the crankshaft was made $\frac{1}{16}$ in. less than the required throw.

In welding, heat was applied first to one side and then to the other, so as to heat the webs evenly, and the building-up process was alternated from one web to the other, so as to avoid distortion. After welding both webs, the whole was turned over and the other side of the web was built up in the same manner.

Some interesting work has been done on machines much different from what the machines were designed to do. For instance, in one case a 6-in. valve began leaking past the thread that held the valve seat to the body, owing to the bad condition of the threads. The remedy was to recut the threads and put in a new seat, but there was no lathe either at the plant or in the vicinity. The valve was required immediately, and it was decided to do this threading by means of a drill press.

The valve was placed on the table of the drill press, and a boring bar was used to clean out the old thread. Then the end of the boring bar was threaded for about three or four inches, twelve threads to the inch, which corresponded with that on the new seat. A blind flange was drilled and threaded to receive the threaded end of the boring bar, and it was then secured to the boss of the drill press, central with the spindle on the drill.

After disconnecting the feed on the spindle, the bar was screwed into the threaded flange in order to get the proper location of the threading tool. The cutting tool was then fitted in the boring bar and adjusted as the thread was deepened.

In one instance it was necessary to rebore the guides of a small engine. This job was done by using an

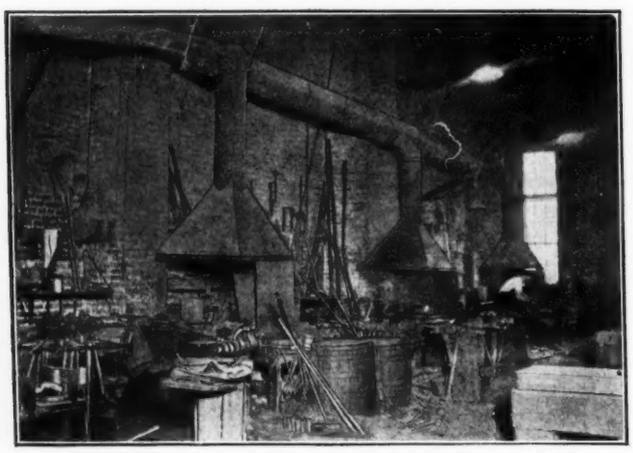


FIG. 24. FORGE AND BLACKSMITH SHOP

upright drill press. A guide *A* was rigged as shown in Fig. 16, being clamped to the side of the drill press *B* and the engine casting *C* located on parallels. A boring head *D* with roughing tools in advance of the finishing tools and a steadying roller, not shown, immediately behind them, enabled the job to be completed in a satisfactory manner.

In one shop a machinist had an emergency job of turning a small diameter long shaft on a large lathe, but the jaws of the steady rest could not be made to reach and support the small shaft, and on account of its length a steady rest of some kind was necessary. The machinist, therefore, secured a straight-tail dog to the tool post, as shown in Fig. 17, and adjusted it to bear on the shaft. This prevented chattering.

Sometimes it may be necessary to cut a thread of greater pitch than the change gears will permit. In one instance only a 24-in. lathe was available, and it

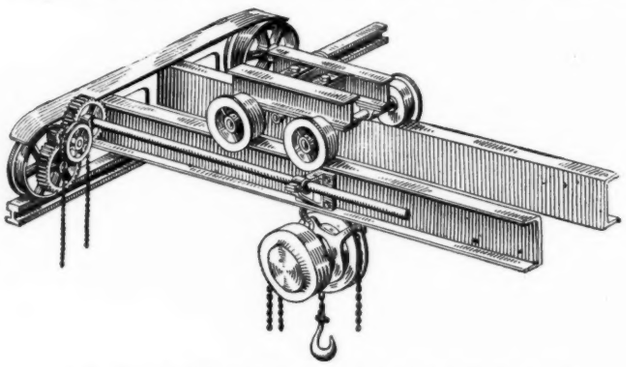


FIG. 25. HAND-OPERATED TRAVELING CRANE

was desired to cut a $2\frac{1}{2}$-in. pitch thread, with no suitable change gears. The only gears that could be used for a special rigging were a pair of $1\frac{1}{4}$-in. pitch, having a ratio of $2\frac{1}{2}$ to 1. In order to use them, a screw of 1-in. pitch was needed. This difficulty was overcome by making a new lead screw with a pitch of two threads per inch, which was substituted for the regular screw in the lathe. The nut was babbitted to fit it, and with the lathe geared as if it were to cut two threads per inch with the regular 4-pitch lead screw, a left-handed 1-in. pitch thread was cut on the end of a $1\frac{1}{8}$-in. shafting. It was then supported along the front of the lathe by a bearing in front of the headstock and one carried by a separate support detached from the lathe itself. The threaded end of the shaft ran in a babbitted nut that was fastened to the top of the lathe carriage, as indicated by Fig. 18.

A drive with reverse motion was obtained from a countershaft, the cone and driving pulleys being turned end for end in its bearings which, of course, necessitated shifting the drive pulley on the lineshaft.

The larger of the two gears was bolted to the face-plate, and the smaller one was keyed to the $1\frac{1}{8}$-in. shaft, on which was also mounted a 30-in. driving pulley belted to the small step of the countershaft cone pulley.

Centering circular work on a vertical boring-mill table can be hastened by using the method shown in Fig. 19. The work to be machined is clamped in place on the table by toe clamps. Four $1\frac{1}{2}$-in. hardened dowel pins are placed at equal distances from the center of the boring-mill table. Four $1\frac{1}{2}$-in. tapered wedges, graduated in quarter inches, as shown, are then driven in between the dowels and the piece to be machined. When the same graduation is lined up with the center of the dowels on opposite sides, the work is centered. The centers of the dowel pins are located by clamping a scriber in the toolpost, thus marking the correct distance from the center when the table is revolved.

Numerous machines other than those here mentioned, are used in some of the shops of large central stations. The New York Edison Co. maintains an exceedingly complete machine shop. In addition to the general run of lathes, planers, shapers, milling machines, radial drills, boring mills, screw machines and small speed lathes in the machine shop proper, there are other tools

in the construction department, each machine being either individually motor-driven or arranged with motor drives in group form.

Fig. 20 illustrates a motor-driven shear used in the construction shop. Fig. 21 shows another type of shear and Fig. 22 is a set of bending rolls. Fig. 23 is a bending machine used for any job that requires bending, from right-angle bends for copper busbars to sheet iron for the uptake of smoke flues. The work shown in the machine is that of bending a half-section of such a job, the bottom end being square and the top round, the machine crimping the metal in changing the form. It is belted to a motor. If the plant is of considerable size, a forge shop will be necessary. One is shown in Fig. 24, having three fires. With such an equipment all kinds of hand forging and blacksmith work can be done. An essential that should not be neglected is a crane. Fig. 25 shows a small hand-operated traveling crane running on I-beams from one side of the shop to the other. This facilitates the work of moving heavy pieces.

FIG. 26. A CONVENIENT SWING CRANE

A swing crane conveniently located will handle heavy work from the floor to the machine, or from one machine to another. Fig. 26 is an illustration. As the crane arm swings it is capable of handling work within the diameter of a circle equal to twice the length of the arm. Unfortunately, a casual visit to power-plant machine shops does not enable one always to find a special job on hand, therefore, much of the work that was seen was of the every-day variety such as is done by the average machinist.

Expedients Employed in a War-Time Central Station

By Carroll F. Merriam

An account of war-time expedients in a power plant situated at Bakou, Russia, may be of interest. Repairs of decidedly unusual nature were made necessary by the impossibility of getting deliveries and the fact that much of the equipment had been made by the enemy. Cut off, as Russia was from the rest of the world, this station was forced to keep running in spite of the difficulties that presented themselves.

Before the war was over, the reserve supply of boiler tubes had been used and no others of the right size were to be had. It was, however, possible to get those which were a little small and some two feet too short. Pieces of the old tubes which were still in usable condition were welded in a forge to the ends of the small tubes and used with good results and with no accidents.

Ordinary glass tubing had to be used for the water glasses, and although the breakage was high, still, considering the lower price, this practice in the end proved less costly.

Considerable difficulty was experienced with a turbine governor because the driving gear had become so worn that it was at last necessary to shut down. Several attempts were made to replace these parts, first filling in the wear of the teeth with white metal, which lasted hardly more than twenty-four hours, and later machining new gears with the crude machines in the plant. These failed, and there was nothing left but to run the turbine without any governor but the safety stop, in which a great deal of confidence was not to be placed. Some difficulty was experienced in synchronizing, but once done the machine continued to run perfectly.

Very curiously, another large machine connected to the same system developed similar trouble shortly after and had to be run in the same way. This was considered more dangerous, as its regulation was dependent on the tie line connecting the two stations. As might be expected, in time there was an accident which cut this machine out of commission. One of the operators noticed the change in the sound of the machine and was able to get it under control even before the safety speed limit tripped. For the rest of the night this turbine was governed by hand.

The system operated satisfactorily, however, for more than three years with from four to six machines on the line, two of the most powerful without governors.

On account of the failing of the diaphragm between the first and second velocity stages of the wheels, one entire set of blading was destroyed. It was found that the metal was seriously oxidized and that instead of being an accident to this particular turbine, it was something that was about to happen in all the turbines of that make. It was then necessary to remove this stage from four turbines. The effect was a slight loss in capacity but a considerable increase in steam consumption. However, three of these machines have run for three or four years without any mishaps.

The difficulty with the condenser tubes seems to be peculiar to plants of that locality, and it is evident that the brass used is not suited to the salt water. The older units showed no traces of unusual corrosion, but the newer ones were severely attacked.

Hairline cracks, which were found generally on the lower side of the tube were closed by tinning the whole of the outside surface. Anything that was not closed in this way was soldered and then tested with air pressure under water. It finally appeared that the walls were too thin for this, and a method of depositing copper electrolytically was tried. I expressed the opinion that this would have been a success had the tube first been filled with a fusible alloy which could have been melted away after the copper had completely covered the leak. However, before this was tried, a supply of tubes a little short was found, which were lengthened by pieces cut from the others.

Two interesting cases occurred where a machine burned so that a portion of the laminations were melted. At first it was thought possible to cut away the damaged metal and thus hasten the repair. To test the effectiveness of this, a wooden bar was set in the place of the burned one and the speed brought up to normal. Then the field was slightly excited. This experiment was conclusive, for before the excitation could be brought up to normal the wood caught fire, showing that, although apparently all the damaged iron had been removed, still the insulation between the sheets had been

so broken down that the eddy currents soon heated the iron enough to burn the wood.

This, then, meant that the whole stator would have to be rebuilt, and sixty women were employed in three shifts, night and day for three weeks, in cleaning the iron and replacing the paper. All the bars were removed, wrapped in tinfoil and given a test for the insulation, which was beginning to break down. Those that did not stand the test had to be rebuilt with whatever means were at hand. Repairs on the two 12,000-kva. machines that were burned each time required from four to six weeks each time.

Several transformers had to be rewound, but the most interesting cases of work of this kind were providing for the cooling of two that were delivered in 1916 without oil casings. At last a plain sheet iron box was made and placed in a concrete cistern supplied at the bottom with fresh water. An overflow at the top so regulated the water level that in case of a leak there would be a slightly greater pressure on the inside which would force the oil out rather than let the water in. These transformers operated even when overloaded above capacity with the temperature of the outside air as high as 104 deg. F., without undue heating.

Renewable Fuse for Protecting Polyphase Motors Against Single-Phase Operation

Large industrial plants have been demanding and electrical manufacturers have been working for years to develop a means to prevent polyphase motors running single-phase. Motor and controller manufacturers have devoted a large proportion of their experiments

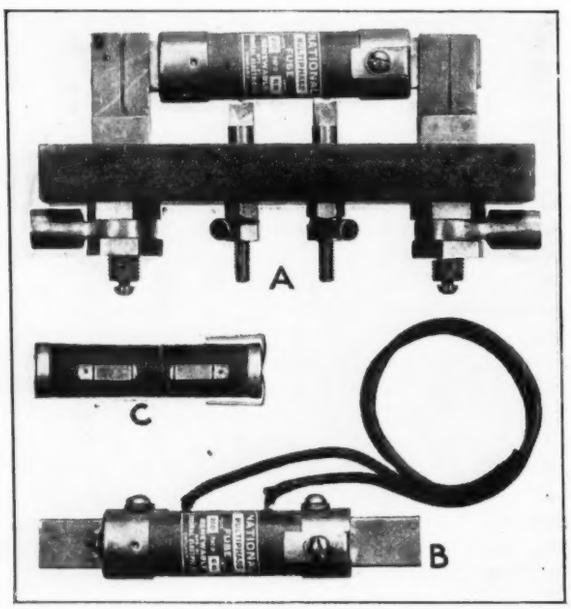


FIG. 1. MULTIPHASE FUSES FOR BACK AND FRONT CONNECTIONS

to attempting to utilize a relay device in connection with the controlling apparatus, but inasmuch as the blowing of one fuse in a multiphase circuit does not operate the circuit breaker or overload release, the problem has been a difficult one. Probably more motors burn out from single-phase operation than from any other cause.

The Federal Electric Co., of Chicago, has developed a low-voltage auxiliary coil which is embodied in the renewable cartridge, and as the cartridge can go into the case in but one position, it easily makes the auxiliary connection with the fuse case itself. Reference to Fig. 2 will show the fuse circuits. In addition to the regular fuse element in each cartridge there is a coil of wire. This coil is connected in parallel with another one of the fuses; for example, the coil in *C* is connected to the terminals of *A*. The fuse being of low resistance and the coil of comparatively high resistance, the latter will not affect the value of the current flowing through the fuse element. But should one fuse blow out, say fuse *A*, then the coil in fuse *C* which is connected to the terminal of *A* will be inserted directly into the motor circuit, which will result in heating the coil. In addition to this the current through fuses *B* and *C* will be increased due to single-phase operation. As a result fuse *C* will blow before the motor has time to overheat. As an example, the 100-ampere 250-volt size fuse is timed to blow, running single-phase, within 3½ min., on 80 per cent load. Fig. 1 *A* shows one of the fuses arranged for back connection, the two small terminals being for the coil connections. Fig. 1 *B* is for front connections and 1 *C* the renewable time-limit cartridge. Connection is made to two contacts on the inside of the fuse case by two flat contacts on the side of the cartridge.

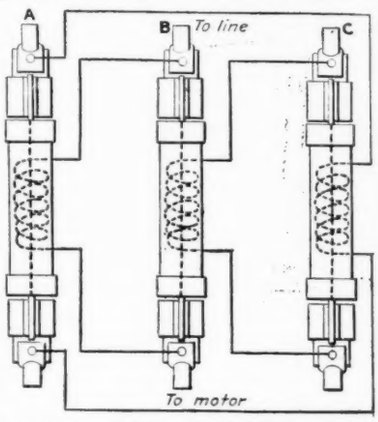
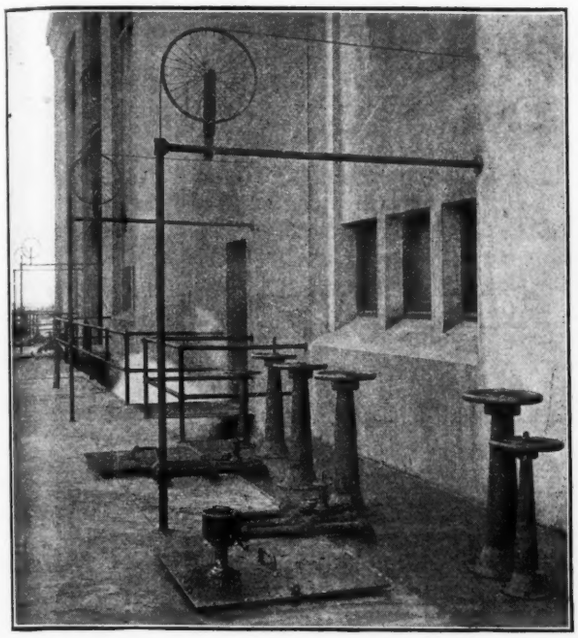


FIG. 2. CONNECTION DIAGRAM FOR MULTIPHASE FUSES

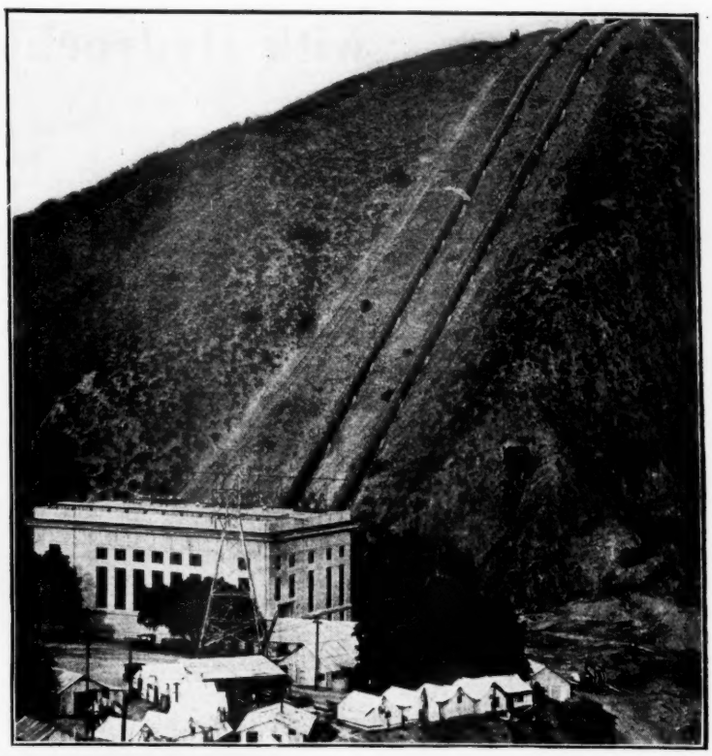
As a fuse the new device is so constructed that it withstands the high starting current of motors, yet protects the running load within the limits prescribed by the Underwriters' Laboratories, Inc. It is powder-packed, which is the best-known fuse practice. It has the metallic "telltale" indicator which shows in plain view upon the outside of the fuse the rated amperage of the element with which it is loaded. As the fuse is made for operation on multiphase circuits, it acts as a circuit breaker; that is, when one fuse blows, the auxiliary device makes one of the other elements in another fuse blow, thereby breaking the circuit entirely and eliminating the possibility of single-phase operation.

The expectation of lower prices for coal in the near future was declared to be without foundation by Chairman Clark of the Interstate Commerce Commission in a letter which was read at the annual convention of the Michigan-Ohio-Indiana Coal Association held at Cedar Point, Ohio, recently. To quote from the letter:

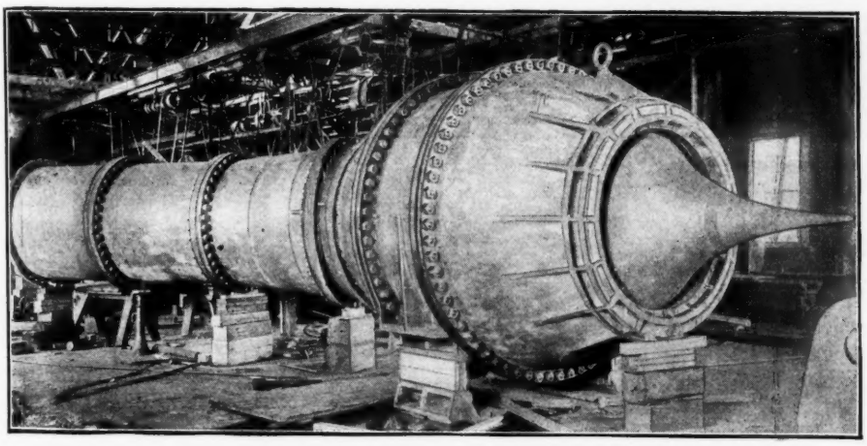
I regard it as extremely unfortunate that there should have been so much agitation in regard to an early reduction in rates on coal or other commodities, and in some instances on freight traffic generally. I think that the result of these rumors, which in the main have no real foundation, has been to stagnate industry and commerce. There is not to my knowledge now pending before the commission any formal proceedings in which general reductions of coal rates under Section 1 of the act are sought.



Old bicycle wheels were used in this gage on the auxiliary fuel-oil tank at the Long Beach (Cal.) steam plant of the Southern California Edison Co. The chains are attached to floats in the tanks and to gages inside the plant.

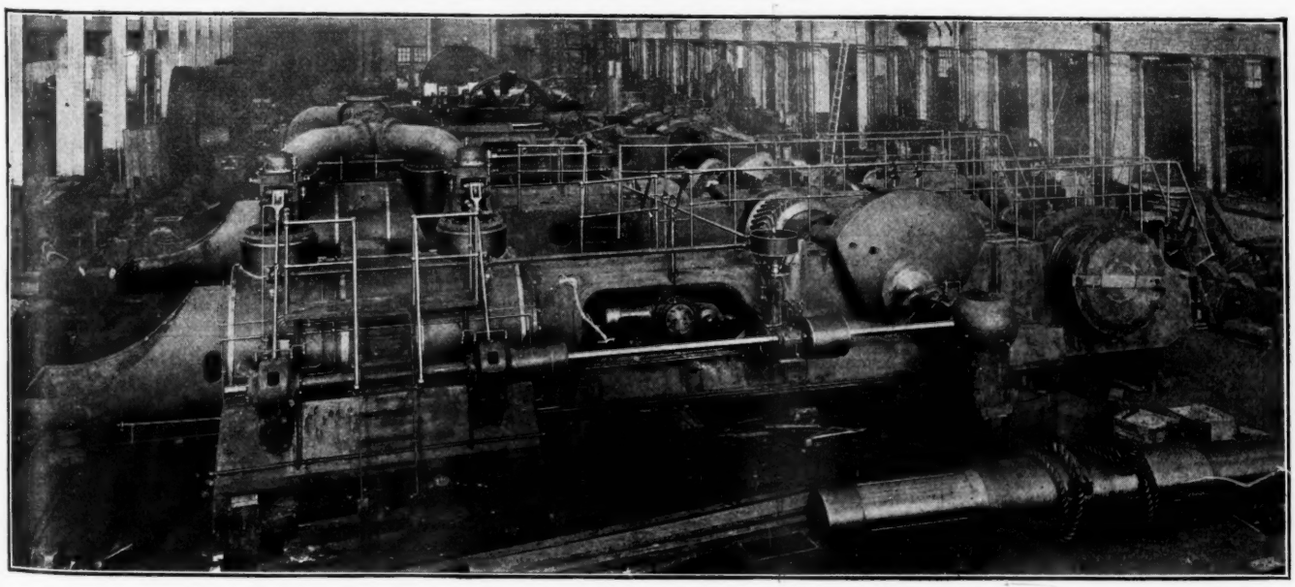


San Francisquito Plant No. 2, a recent addition to the Los Angeles aqueduct power system. It contains two 22,000-hp., vertical, reaction turbines working under a 530-ft. head. Power is carried at 110,000 volts over a 50-mile line to Los Angeles.



Left—A 54-in. needle valve, one of three at Roosevelt dam. It operates at a 117-ft. head and controls a flow of 1,600 cu.-sec.-ft. To open it from zero to nine-tenths requires 27 minutes with a 3-hp. motor and 19 minutes with a 5-hp. motor. The maker was the El Paso Foundry and Machine Co.

Below—Two big duplex unaflow engines, designed for a normal rating of 4,200 hp. (2,100 hp. per cylinder) at 190 lb. steam pressure, 150 deg. superheat, 110 r.p.m. Both cylinders are of 40-in. bore and 48-in. stroke. The drive is by herringbone gears. Both are Nordberg-Todd engines and are being installed in the American Sheet and Tin Plate Co.'s rolling mill.



Removing Scale from Surface Condenser Tubes with Hydrochloric Acid

By NORMAN G. HARDY
Chief Mechanical Engineer, Arizona Copper Company, Ltd.

IN POWER plants where circulating water for surface condensers is supplied from cooling towers or ponds, the evaporation causes a considerable concentration of salts. If, as is usually the case, the makeup water itself carries considerable amounts of calcium or magnesium carbonates, a comparatively hard scale is formed in the condenser tubes. At best it is difficult and expensive to remove this scale. The usual method is to use a power-driven revolving cutter. If the tubes are in good condition, mechanical cleaners may be used without apparent injury, but after they become brittle as a result of dezincification the use of mechanical cleaners will cause a serious loss of tubes.

Among the many methods of cleaning that have been suggested is the use of a dilute solution of hydrochloric acid, but it seems to be the general opinion that this method is rather dangerous, because of possible action of the acid on the metal parts of condenser and tube packing.

At the power plant of the Arizona Copper Co., Ltd., Clifton, Ariz., hydrochloric acid has been used to clean condensers for the last two years with very good success. It is not claimed that this method is entirely satisfactory or that it is suitable under all conditions, but the success it has met with in the plant mentioned makes it of sufficient interest to be worth describing.

Apparatus and Process Described

The general arrangement of apparatus is shown diagrammatically in the illustration.

The condensers on which this outfit is used have a tube area of 7,600 sq.ft. in 2,500 Muntz metal tubes ¾ in. in diameter by 15 ft. 1 in. long and are used for condensing steam from 2,000-kw. turbo-generators. The condensers have two passes with a vertical diaphragm between water inlet and outlet compartments.

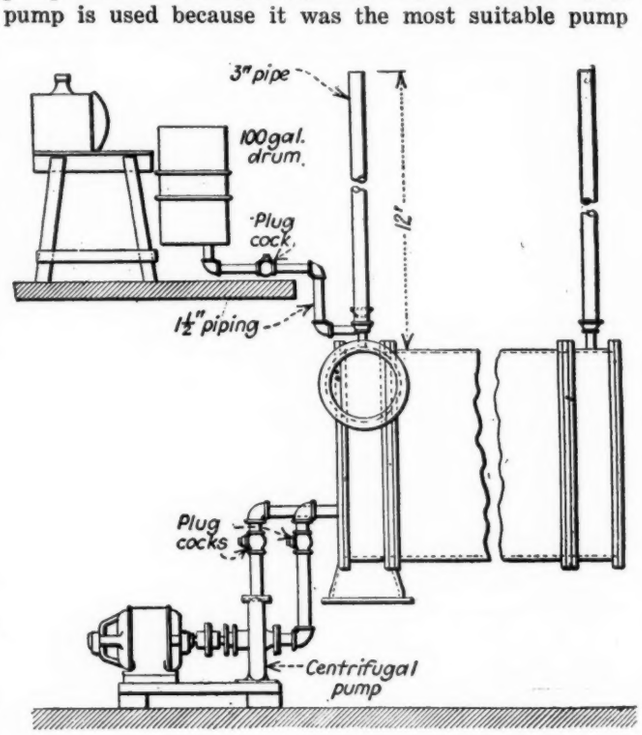
Before using the acid, both heads are removed from the water boxes, the tubes are washed out with a hose, the scale is cleaned from the water boxes, the heads, and so far as practicable, from the tube sheets also; after drying thoroughly, water boxes, heads and tube sheets are painted with two coats of roofing cement, to eliminate all chances of corrosion of the permanent parts of the condenser.

At first an acid-proof paint was tried, with the idea of maintaining a coating that would only have to be replaced occasionally, but it was found that the coating would not remain serviceable from one cleaning to the next. After trying several asphaltic paints, it was decided that roofing cement, such as is ordinarily supplied for cementing the seams of prepared roofing, was best because it is sufficiently acid resistant, can be easily applied and dries quickly.

Cover plates with gaskets are next fastened over water inlet and outlet with capscrews tapped into the water box. The heads are then replaced and the apparatus connected up as indicated in the figure. A temporary platform is erected on the operating floor, from which the acid is poured into the mixing tank. The latter is a 100-gal. steel drum with the head cut out, and a 1½-in. pipe connection from the bottom of the tank to the top of the water box of the condenser.

Vent pipes about 12 ft. long are placed at the top of each water compartment. The water boxes are tapped for 1½-in. pipe and have a short nipple and reducer to connect to the 3-in. vent pipe. These vent pipes are very necessary, and it has been found that gas will blow water over if a height of less than 12 ft. is used.

To circulate the solution, a 2-in. brass centrifugal pump with direct-connected motor drive is used. This pump is used because it was the most suitable pump



ARRANGEMENT OF APPARATUS FOR CLEANING CONDENSER WITH HYDROCHLORIC ACID

available for the work. It is desirable to circulate the solution at as high velocity as possible, as there is a tendency for the gases generated to force the solution out of the tubes. By circulating the solution rapidly, these gases are forced to the water boxes, whence they escape to the atmosphere.

The acid used is commercial hydrochloric, averaging about 24 per cent HCl. It is estimated that the water boxes and tubes will hold 7,800 lb. of water, and 1,000 lb. of acid is used for cleaning, making the solution about 3 per cent HCl. A stream from a ¾-in. hose is used for supplying water and the time required to discharge a measured quantity to the mixing tank is noted. From this the length of time necessary to empty one carboy of acid, with water flowing into the tank continuously, is calculated. Having the outlet from the mixing tank open, the water from the hose and the acid from the carboy are delivered into the mixing tank at a predetermined rate, whence they flow into the condenser

continuously until it is filled. This is a rather crude method of proportioning the mixture, but it has been satisfactory in practice.

As soon as the level of the solution in the condenser rises above the pump suction, the pump is started. It is kept running for four to five hours, by which time the acid is entirely neutralized. The solution is usually not drained from the condenser until the following day. After the solution is drained, one head is removed and each tube is washed out with a stream of water. Each one is then brushed with a round wire brush on the end of a ¼-in. pipe, water being supplied to the brush through the pipe handle.

The amount of scale actually dissolved is relatively small, being equivalent to a thickness of about 0.001 in. for the condenser and mixture described. But the great benefit of acid treatment is that it softens and loosens scale, so that it can easily be removed by washing and brushing. For this reason, if the condenser is very dirty, it will probably be more economical to treat it several times with a weak solution, washing out the loosened material between treatments, than to use a stronger solution.

High Cost and Possibility of Injury

The principal objections to the use of acid for cleaning are high cost and the possibility of injury to tubes and packing. The first of these is undoubtedly justified and eliminates this method in any case where the tubes are in good condition and the scale not too hard to permit mechanical cleaning.

With regard to the second objection, it can be positively stated that the experience of the Arizona Power Co., Ltd. for two years past does not indicate any serious deterioration of tubes as a result of the use of acid for cleaning. The condensers on which this method has been used have been in service for 7½ years. For several years mechanical cleaners were used very satisfactorily, but as the tubes became brittle with age, the tube loss increased until two years ago it amounted to several hundred tubes at each cleaning. Since using acid for cleaning, this loss has been negligible. In these condensers the tube sheets are of cast iron and some trouble was anticipated from the effect of acid on these. Some indication of local corrosion of tube sheets and heads resulting from defects in the paint film has actually been found. Present indications, however, are that this will not cause sufficient damage to be serious for several years. There is, up to the present, no indication that the tube packing is being injured by the acid solution used.

TABLE I. COMPARISON OF COSTS OF CONDENSER CLEANING

Cost of Cleaning a 7,600-sq.ft. Condenser with Hydrochloric Acid.

Labor:	
Preparation, involving opening up the condenser, washing it out, drying, painting and connecting up of apparatus	$15.08
Actual cleaning operations, involving putting in and removing the acid, disconnecting the apparatus and opening up the condenser	$11.77
Washing and brushing	$12.44
Testing for defective tubes and closing up the condenser	$4.42
Total labor cost	$43.71
Materials:	
Commercial hydrochloric acid — 1,000 lb. at $14.70 per 100 lb	$147.00
Brushes, paint, etc.	$5.00
Total cost of acid cleaning	$195.71

Cost of Cleaning a 7,600-sq.ft. Condenser with Air-Driven Mechanical Cleaner

Labor:	
Preparation, involving opening up the condenser and preparing the platform and cleaner, etc.	$7.53
Drilling the tubes	$31.40
Washing out	$4.66
Testing for defective tubes, closing up, removing platform, etc.	$7.53
Total labor cost	$51.12
Materials:	
Cleaner tools, machine repairs, etc.	$10.00
Total cost, excluding tube renewals	$61.12
Tube Renewals:	
200 tubes at $4.79 each	$958.00
Labor, 200 tubes at $0.35 each	$70.00
Total cost of tube renewals	$1028.00
Total cost of mechanical cleaning	$1089.12
Total cost of acid cleaning	$195.71
Extra cost of mechanical cleaning	$893.41

Laboratory Tests

Before starting to clean with acid, laboratory tests were made of the effect of hydrochloric-acid solutions on cast iron and tubes. Small blocks of cast iron were drilled and tapped for standard packing nuts and a short section of tube packed in each. These were immersed for one week in hydrochloric-acid solutions of various strengths up to 10 per cent HCl. The only apparent effect on the tubes was a slight surface dezincification which gave them a copper color. The iron was not changed in external appearance, but it became soft enough to be cut easily with a pocket knife and the chips appeared much like soft carbon.

TABLE II. ANALYSIS OF COOLING WATER IN PLANT OF ARIZONA COPPER COMPANY, LTD.

Solids	Parts per Million — Sample 1	Sample 2	Sample 3
Organic	52.0	360.0	300.0
Silica	36.0	46.0	108.0
Aluminum and iron oxides	2.0	3.0	4.0
Calcium carbonate	160.0	160.7	87.1
Magnesium carbonate	12.0	.....	.....
Sodium chloride	474.9	2,859.5	4,122.4
Calcium chloride	37.7	871.8	1,317.0
Magnesium chloride	4.9	1,013.0	83.6
Calcium sulphate	25.8	.....	.....
Magnesium sulphate	16.7	.....	139.0
Sodium sulphate	....	200.0	.....
Total solids	832.0	4,602.3	6,161.1
Alkalinity (parts H_2SO_4 per million to neutralize)	176.0	180.0	88.0

Sample No.	Description
1	San Francisco River water
2	Well water
3	Cooling tower water when supplied with about half and half of each of the above waters for makeup.

With labor and material costs as they were in the early part of 1921, the cost of cleaning a condenser, both with hydrochloric acid and with air-driven mechanical cleaners would average as shown in Table I.

With the condensers in present condition, at least 200 tubes would be lost by mechanical cleaning in excess of the number lost by acid cleaning.

If the condenser tubes were in good enough condition to permit mechanical cleaning without injury, the cost of mechanical cleaning would be $134.59 less than the cost of acid cleaning.

The data given represent actual costs at Clifton. The cost of the acid quoted will seem high, and it should be explained that about 85 per cent of it is freight from the point of manufacture to Clifton. The cost of the condenser tubes quoted is for tubes purchased early in 1919 and is probably higher than present costs.

Condensing System and Analyses of Water

In this connection some information regarding the condensing system and analyses of water used will be of interest.

Steam from the turbo-generators is condensed in the surface condensers already referred to, while the steam from the reciprocating engines is condensed in a barometric condenser. The latter is about 10 per cent of the total steam condensed. Circulating water from the surface condensers is cooled in an open cooling tower, and that from the barometric condenser in a spray cooling pond. The pond and tower sumps are connected through an equalizing pipe, and it is found that the concentration in the pond and that in the cooling tower are very nearly the same.

There are two sources of cooling tower makeup water; the water of the San Francisco River near by, and the water from a well in the bed of this river. It is the practice to pump makeup water from the river when it is clear; at other times water from the well is used. In order to keep the concentration of salts to a minimum, about 1.5 times as much makeup water is supplied to the cooling system as there is steam condensed. This permits frequent blowing down and thus holds the concentration low.

Typical water analyses are given in Table II.

The concentration of water in the cooling tower shown by the foregoing analysis is slightly lower than the maximum that is considered allowable. It has been found that at concentrations above 10,000 to 15,000 parts per million of total solids, the rate of scale formation is greatly increased. It is therefore the practice in this plant to supply sufficient makeup water to hold the total solids in the water below 10,000 parts per million.

TABLE III. AVERAGE COMPOSITION OF CONDENSER SCALE IN PLANT OF ARIZONA COPPER COMPANY, LTD.

	Per Cent
Calcium carbonate	91.5
Magnesium carbonate	3.5
Aluminum and iron oxides	1.0
Silica	3.0
Organic matter	1.0
Total	100.0

The average composition of the scale in the condenser is given in Table 3.

This scale is moderately hard and adheres closely to the tubes, but becomes rather brittle when dry.

Whitney Free Floating Coupling

A free-floating coupling, primarily designed to allow for misalignments, either parallel or angular, has been designed by the Kay Manufacturing Co., South Norwalk, Conn. The coupling is compact and simple in construction, contains no flanges or pins and, when connecting two machines, gives a positive driving joint, but allows each machine to run freely in its own bearings.

Referring to Fig. 1, it will be seen that the coupling consists of two hubs and a special design of driving link. Each hub is made with a square socket in the inner end, and the outside surface of each hub is rounded as a bearing for the retainer ring. The link, which carries the load, is made with square ends, with edges slightly curved to permit of free movement in the hub socket in any direction out of alignment. It will be seen that the corner of one end of the link lines up about halfway between the corners of the other end. This permits of free movement of the link in the hubs.

FIG. 1. HUBS AND LINK OF COUPLING

The casing fits over the hubs and is held in place by two retaining rings that are made to fit the curvature of the outer surface of the hubs. Each ring is secured to the casing by small screws. The casing and retaining rings are free of any connection to the hubs and have no connection with them other than that due to friction.

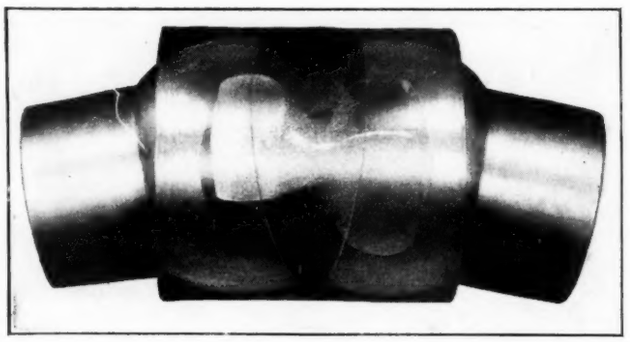


FIG. 2. PHANTOM VIEW OF THE ASSEMBLED COUPLING

Fig. 2 is a phantom view of the coupling complete. It will be seen that there is no projection, the outer ends of the coupling being secured to the shift by means of a key and a flush setscrew. This coupling is made in several sizes for ¾-in. to 6½-in. shafts.

Operation with Pulverized Coal

BY A. J. DIXON

A test to determine the commercial efficiency of pulverized coal as a boiler fuel has been in process in the power plant of the Rialto Building, St. Louis, for a number of weeks. The fuel consists of pulverized bituminous screenings from the Terre Haute district in Indiana. Analysis of this coal shows in percentage: Fixed carbon, 36.13; volatile, 36.82; sulphur, 2; ash, 20; moisture,, 5.05. It has a thermal value of 10,762 B.t.u. per pound as fired, or 11,300 B.t.u. per pound dry. The coal is ground to a practically impalpable powder.

A horizontal return-tubular boiler 20 ft. long and 6 in. in diameter is used for the experiment. It was originally equipped with a down-draft furnace. Owing to lack of headroom the boiler is set low, so that the grate of the secondary furnace in the original setting was flush with the boiler-room floor.

In preparing for the test, the down-draft furnace was taken out and a dutch oven was built as shown in the illustration. This constitutes the furnace, or primary combustion chamber. The fuel is blown into this furnace through a 6-in. galvanized-iron pipe flattened at its outlet to form a horizontal slot about 1¼-in. wide and 16 in. long, as shown, so that the atomized coal blown through this orifice spreads out in a fan-shaped spray.

The fuel inlet is flanked on each side by an opening 8 in. square, in the furnace wall, as shown at the right. Air passes through these openings into a space between the outer wall of the furnace and a firebrick lining, and then into the furnace through openings near the bottom of the lining, as indicated.

These air currents supply a portion of the oxygen necessary for combustion, but their principal function

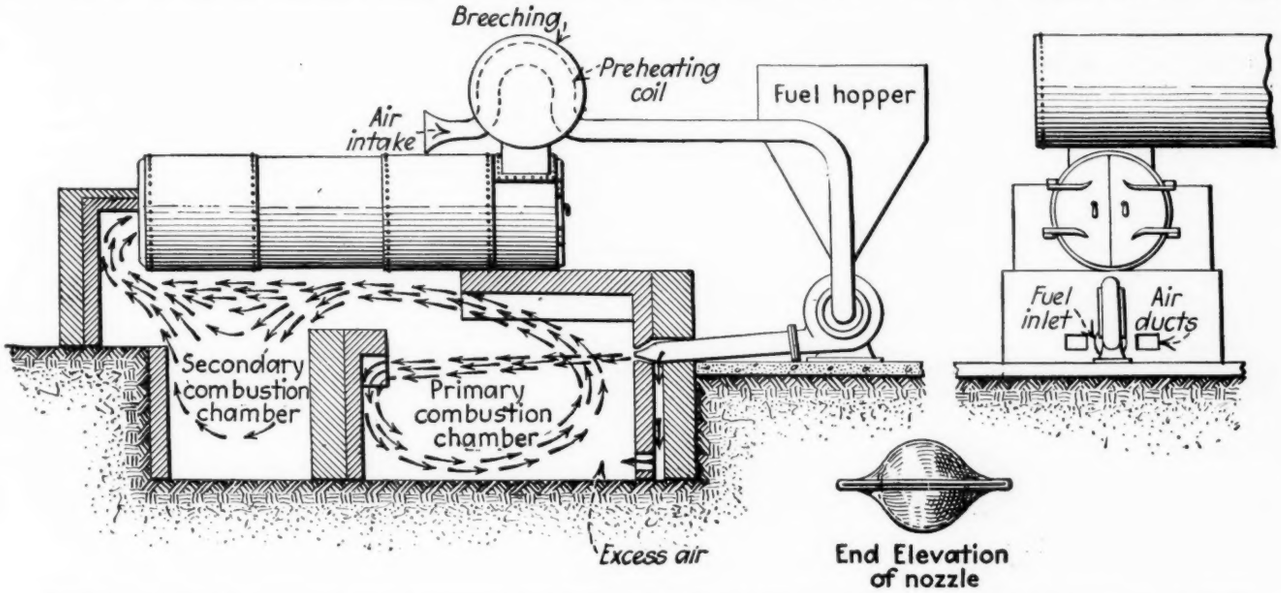
is to cool the fine ash deposited on the furnace bottom and prevent fusing and caking. Admission of air beneath the spray of fuel also opposes any tendency of the particles to settle to the bottom of the primary combustion chamber before ignition and combustion can occur.

The bridge wall of the original furnace was left in place, and a firebrick arch was built into it so as to produce the 9-in. overhang. The purpose of this arch is to deflect the burning combustibles, as they impinge against the wall, and curl them downward and forward so that they will again traverse the firing zone.

Owing to the agitation produced by the revolving vanes in the feeding apparatus, each minute particle of the atomized fuel that is blown from the flattened orifice of the feed pipe is presumed to be enveloped in a relatively large volume of air. These particles are projected into a region heated by radiation from the incandescent

In the smoke-box at the front end of the boiler the average draft pressure produced by a chimney 140 ft. high is 0.44 in. of water. The draft pressure at a point in the primary combustion chamber above and a little forward of the bridge wall is 0.15 in. The draft is due entirely to natural chimney suction. The volume of air flowing through the feed pipe just suffices to spray the fuel, no blast effect being produced. The temperature is only 200 deg. F. at the base of the chimney, due to absorption of heat from the flue gas by the air supplied to the feeding apparatus. The air-intake pipe, which is 7 in. in diameter, curves through the breeching, as shown, and thus exposes an area of about 14 sq.ft. to the heating effect of the gas. By this means the air is preheated to a temperature approximately 146 degrees Fahrenheit.

A 2-hp. direct-current motor running at 1,800 r.p.m. drives the blower. A double-stage speed-reducing



ARRANGEMENT OF SETTING FOR BURNING PULVERIZED COAL, LOCATION OF AIR DUCTS IN FURNACE FRONT AND APERTURE IN FEEDING NOZZLE

furnace arch to a temperature of about 2,300 deg. F. Ignition of the particles and distillation of their volatile constituents immediately ensue. Complete combustion of the volatiles occurs, as the gas current streams back from impact with the bridge wall and circles the furnace in its passage toward the opening above the bridge wall. A portion of the fixed carbon is likewise consumed in the primary combustion chamber, and complete combustion of the latter is effected in the secondary combustion chamber back of the bridge wall.

The test is being conducted under a handicap, owing to the inadequate size of the feed pipe and the restricted area of the back connection, or the space between the rear wall of the setting and the boiler head. Owing to these conditions it has been found necessary to provide openings in the front wall of the furnace for admission of excess air into the upper part of the fire zone. With a properly designed installation all the air for combustion, with the exception of the currents circulating beneath the fuel spray, is supposed to enter through the feed pipe.

The primary combustion chamber, or furnace, has a volume of 300 cu.ft. and the secondary combustion chamber, 150, a total of 450 cu.ft. of combustion space.

mechanism is employed for bringing the motor speed down to 11 r.p.m. for the operation of the device that controls the flow of fuel from the hopper. The full motor speed is, however, available for driving the centrifugal blower which delivers the fuel to the furnace. The casing of the blower is concentric with the periphery of the impeller, instead of expanding into the volute form, as in a pressure blower.

Flue-gas analyses, made at intervals during the test, showed an average of about 13 per cent CO_2 and no CO. An analysis of a sample of the fly ash taken from the back connection showed 0.04 per cent of fixed carbon. Much of the fly ash goes up the chimney with the burned gases and settles on the roofs of adjoining buildings. There is not a particle of soot observable, however, nor the least semblance of smoke. As a matter of fact the combustion of the fuel appears to be practically complete.

The test has shown an average evaporation of 8 lb. of water per pound of fuel as fired. The boiler supplies steam to an engine which would probably show a steam rate of about 35 lb. per hp.-hr., and to a pair of hydraulic-elevator pumps which probably consume in excess of 100 lb. of steam per horsepower-hour.

Hydro-Electric Development at Niagara Falls*

Progress of Power Development at Niagara Falls Compared with the Other Locations –Outline of New Developments Started at the Falls–Rate of Obsolescence in Early and Modern Types of Hydro-Electric Equipment

BY JOHN L. HARPER† AND J. A. JOHNSON‡

BEGINNING with the year 1895 hydro-electric power development was fairly under way, and Fig. 1 shows the progress from then on up to the present time. Fig. 3 shows a comparison between the rate of progress in hydro-electric development at

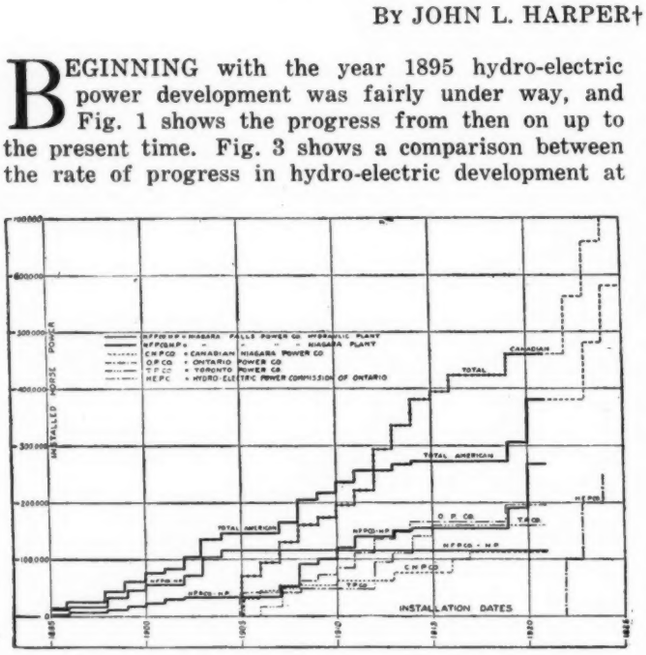


FIG. 1. DIAGRAM SHOWING PROGRESS OF WATER-POWER DEVELOPMENT AT NIAGARA FALLS

Niagara Falls and that in the United States as a whole. From this comparison it will be noted that progress at Niagara has not at all times kept pace with that of the country in general.

The period from 1895 to 1905 might be called the "Decade of Progress" in power development at Niagara Falls, when the various companies at work on the American and Canadian sides devoted themselves to overcoming many natural difficulties and to the building of what were then the largest plants in the world.

In 1906 the governments of the United States and Canada became alarmed at the rapid improvements in the art of power-plant building by which the Falls of Niagara were being made to serve the needs of man and its consequent diversion of water from the cataract, and after due deliberation the Burton bill and the International Waterways Treaty made it unlawful to divert more than a specified quantity of water for power purposes; namely, 20,000 cu.ft. per sec. on the American side and 36,000 cu.ft. per sec. on the Canadian side. These laws cast a blight on the development of the art at Niagara Falls, and the period from 1906 to 1916 might properly be called the "Decade of Stagnation." As an indication of the foregoing, Fig. 2 shows how the development at Niagara Falls lagged behind the progress being made in other parts of the United States in regard to the size of units being constructed, until finally in 1918 Niagara Falls was restored in this respect to its rightful position of first place.

*Abstract from a paper presented before the Annual and Pacific Coast Convention of the American Institute of Electrical Engineers, Salt Lake City, June 21-24, 1921.

†Chief engineer, the Niagara Falls Power Company.

‡Electrical engineer, the Niagara Falls Power Company.

Instead of arbitrarily restricting the amount of water that may be diverted for power purposes, the sensible thing to do is to adopt some measures that will spread as much of the water as is required for scenic beauty evenly over the crests of the falls and to divert all the rest for power purposes, thereby conserving for all time and to the greatest extent both the scenic and commercial values. This division of the flow for scenic and power purposes, as recommended by government engineers, is shown in Fig. 4.

During the war emergency and at the suggestion of the representatives of the War Department, the Niagara Falls Power Co., Hydraulic Power Co. of Niagara Falls and the Cliff Electrical Distributing Co. were merged under the name of the Niagara Falls Power Co., but under the control and management of the owners of Hydraulic Power Co., the merged interests owning all the developments on the American side and controlling the Canadian Niagara Power Co. on the Canadian side. These plants had a total installed capacity of 350,000 horsepower.

Under this unity of control and direction a plan was quickly evolved not only for immediately placing all developed power at the disposal of the government agents for distribution to specified customers who were making the materials vital for war work, but also for the rush development of another 100,000 hp. without sacrifice of permanency of work or efficiency of conversion.

Shortly afterward, however, the government of the United States established the new Federal Power Com-

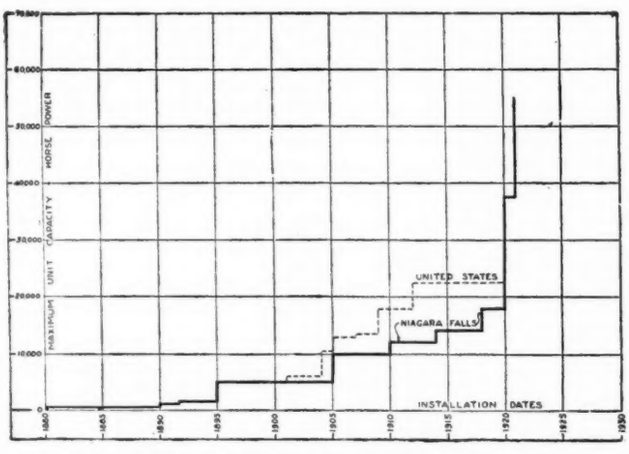


FIG. 2. DIAGRAM SHOWING SIZE OF UNITS INSTALLED AT NIAGARA FALLS COMPARED WITH THE REST OF THE UNITED STATES

mission, one of whose first acts was to give approval to the plans being carried out by the Niagara Falls Power Co. and to issue a license to the company for all the water permitted to be diverted from the American side of the falls in accordance with the terms of the existing treaty. At the same time it recommended

an increase in the allowable diversion and the construction of remedial works to preserve the beauty and grandeur of both the American and Horseshoe Falls.

This license gave formal Federal approval to the plans of development already begun and authorized their completion. These plans include the placing in reserve of the present Niagara plants marked *AB* on Fig 5, the construction of a new waterway from Port Day to carry the water now being used in the Niagara plants to the Canal Basin, the maintenance of Station No. 3, marked *C*, with its thirteen efficient 10,000-hp. units operating under a mean gross head of 217 ft., the extension of this station to the southward and the construction of new units to utilize the 4,400 cu.ft. per

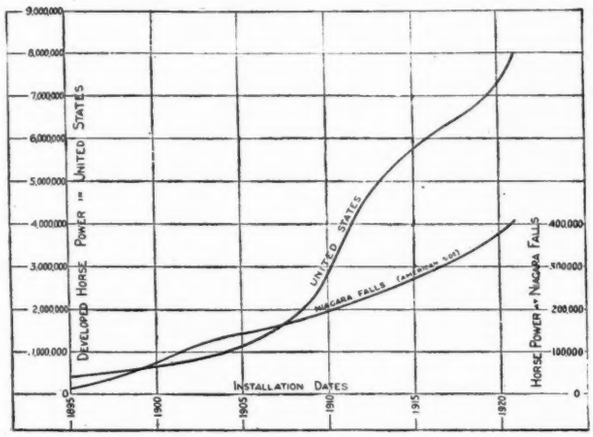


FIG. 3. WATER-POWER DEVELOPMENT AT NIAGARA FALLS COMPARED WITH TOTAL DEVELOPMENT IN UNITED STATES

sec. of water that had not been specifically allotted under the treaty and the water now being used by the Niagara plants. Plans were made so that subsequently the water used by these plants may be re-collected at the most favorable point and carried by tunnel past the lower rapids to a power house in the lower river, where the remaining head may be developed.

The first step of this general plan has already been carried out; namely, the construction of what is known as Station No. 3 Extension[1], marked *D* on Fig. 5, begun in 1918 as a war measure and finished in 1920. This extension contains three units, the combined rating of which is 100,000 hp. and, together with the other plants of the company, uses all the water allowed by the treaty. The second step has just been authorized; namely, the construction of a new tunnel and the installation of the remaining units in an addition to Station No. 3 Extension, marked *J* on Fig. 5.

Another step also has been initiated by the granting of a preliminary permit to the Lower Niagara River Power and Water Supply Co., which allows two years for the presentation of plans for the second, or lower river, stage of the development. The details of this plan have not yet been worked out, and the date of its construction has not been finally decided upon.

Much has been said about the desirability of using the diverted water under the full head of 314 ft. from the upper river to Lewiston, and when the field is entirely without complication, as in the case of the development of water in excess of the present treaty allowance, a one-stage development will undoubtedly be advisable. The reason for the apparent rejection of this plan for the present diversion may be of interest. As a matter of fact, the scheme of development now being carried out does contemplate the use of the full 314-ft. head, but instead of utilizing this head in one plant with a long new waterway involving the abandonment of the efficient plants already built, it will be utilized in two successive stages, the first stage utilizing a gross head of 220 ft. and the second stage a gross head of 94 feet.

Whether power development is made with private or public funds, the consumer pays the cost. A breach of economic laws, therefore, must be immediately reflected in increased rates. A careful study was accordingly made to determine the most economic development, particular attention being paid to the vital factor of interest on the investment during construction and on the unutilized portion of the new works during the period of business development, items which run into millions of dollars owing to the long time required to build and secure a market for these large developments. The general conclusions of this study are expressed in the plans outlined in the foregoing.

The gradual advance in the efficiency of the Niagara power developments is shown in Fig. 6. This chart is very interesting. The left-hand end of the horizontal lines shown for each of the developments indicates the earliest date at which the corresponding efficiency was obtained, and the smooth dotted curve made by joining these points is quite remarkable as showing the progress of these developments. The growth of efficiency, particularly as to those plants employing the headrace-canal type of development, seems to have worked itself out according to quite a definite law and shows the lack of efficiency of the earlier plants. This curve, provided that it holds for the future as for the past, also indicates the great unlikelihood of any con-

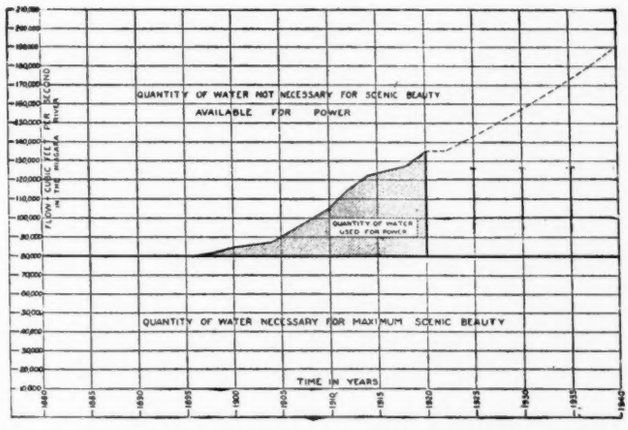

QUANTITY OF WATER NOT NECESSARY FOR SCENIC BEAUTY AVAILABLE FOR POWER
QUANTITY OF WATER USED FOR POWER
QUANTITY OF WATER NECESSARY FOR MAXIMUM SCENIC BEAUTY
TIME IN YEARS

FIG. 4. DIAGRAM SHOWING DISTRIBUTION OF NIAGARA FALLS WATER

siderable further gain in efficiency, and the probability of a very low rate of obsolescence for Station 3 and Station 3 Extension.

It will be observed that the rate of obsolescence of the earlier Niagara power developments was fairly high, decreasing, however, for the later developments, as the art has progressed. The question then naturally arises as to what rate of obsolescence may be expected for this latest development. Obsolescence is undoubtedly a function of efficiency, defining that expression in terms of power and cost, and involves two fac-

[1]Complete description of this installation in *Power*, Sept. 14, 1920.

tors; namely, general operating efficiency which is promoted by the use of compact stations with large reliable units of similar characteristics, and efficiency in the use of water, which latter again involves first, the development of the maximum available head and second, careful design to get the maximum possible power out of the available water at the head developed.

These curves show very clearly how the development of the art quickly ran through the early stages when only very small units were built, of diverse characteristics, and when only a small part of the available head was utilized, and how such plants rapidly became obsolete on account of the great gain to be obtained by building larger and better designed units under higher heads.

Analyzing this latest development in the light of these considerations, we find, first, as to the efficient use of the site, that the entire available 220 ft. has been developed with less than 2½ per cent loss in getting the water to the penstocks; second, that of the power available at the penstock entrances, over 91 per cent is delivered in the form of electrical power at the generator terminals, and finally, that although the size of future units may be increased, such increase of size being permissible when the system of which they are a part increases, there is relatively little more to be gained either in lessening cost or cheapened operation, the present 100,000-hp. three-unit extension requiring but three men per shift to operate it.

These results are so far in advance of previous installations and leave so little room for improvement that it appears justifiable to say that obsolescence of

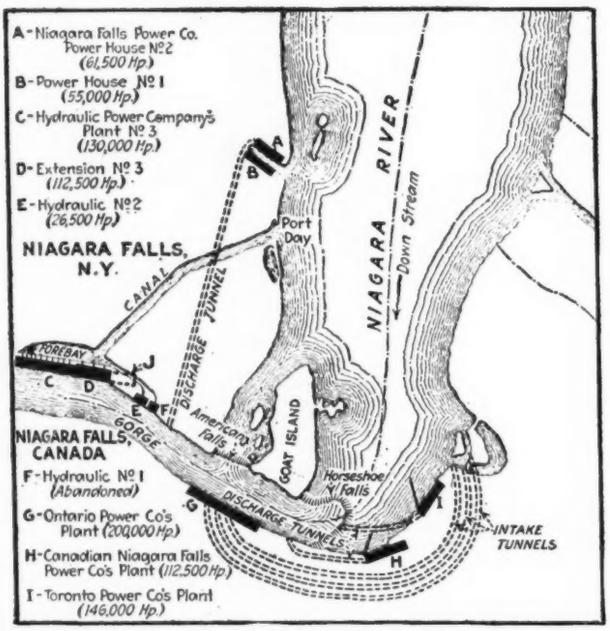


FIG. 5. MAP SHOWING LOCATION OF PLANTS AT NIAGARA FALLS

this plant could be brought about only by some scientific advance in the art of power production of a totally unexpected and revolutionary character.

The completion in 1920 of Station No. 3 Extension with three 37,500-hp. units provides for the utilization of the entire amount of water, 20,000 cu.ft. per sec., which is available under the existing treaty. But there has been, and with the return of normal conditions there will be, a demand for additional power.

Since by act of Congress creating the Federal Power Commission, the United States Government assumed control of the Niagara River situation, it became necessary that the commission's approval be obtained for any further development of power. As no further water is at present available, the only source of additional power is the use of some of the present water under increased head. Naturally, the least efficient of

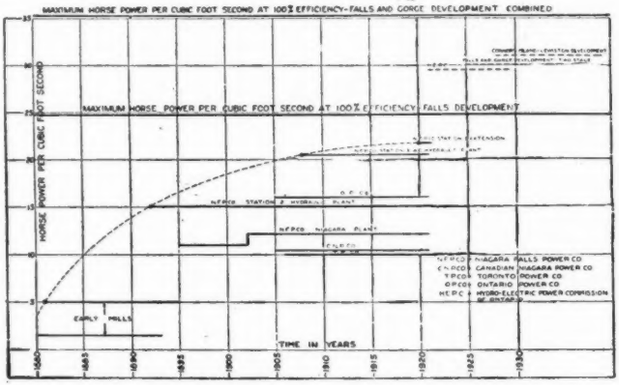

MAXIMUM HORSE POWER PER CUBIC FOOT SECOND AT 100% EFFICIENCY-FALLS AND GORGE DEVELOPMENT COMBINED
MAXIMUM HORSE POWER PER CUBIC FOOT SECOND AT 100% EFFICIENCY-FALLS DEVELOPMENT
HORSE POWER PER CUBIC FOOT SECOND
TIME IN YEARS
EARLY MILLS
NIAGARA FALLS POWER CO
CANADIAN NIAGARA POWER CO
TORONTO POWER CO
ONTARIO POWER CO
HYDRO-ELECTRIC POWER COMMISSION OF ONTARIO

FIG. 6. CHART SHOWING HORSEPOWER OBTAINED FROM A CUBIC-FOOT-SECOND OF WATER DIVERTED FROM THE NIAGARA RIVER

the existing plants would be the one first selected for obsolescence, which in this case is the "Niagara" plant, which, operating under an effective head of 140 ft., obtains but 12.1 hp. per cu.ft. per sec., as compared to 21 hp. per cu.ft. per sec. in the Station No. 3 Extension.

The economic reasons for the plan adopted for the redevelopment of this water have been given herein, and the company is now proceeding under license from the Federal Power Commission with the construction authorized.

The power will be developed in a further extension to Station No. 3 along similar lines to those followed in the already completed extension.

The water will be brought from Port Day through a 32-ft. horseshoe-shaped tunnel at a depth of about 100 ft. below the surface of the ground. From this tunnel the water will be taken to the penstocks through a forebay similar to that provided for Station No. 3 Extension. The construction of this tunnel was started, with fitting ceremonies, on April 25 of this year, and the work is now proceeding rapidly from both ends and two intermediate shafts. It is expected that the first unit of this development will be started on or before May 1, 1923.

It must be borne in mind that the attainment of our highest good must ultimately demand the most efficient use of this power. Nor is efficiency here meant in any narrow sense, but in the broadest sense of the greatest good to the greatest number. Within the next few years we shall undoubtedly see great superpower transmission lines reaching out hundreds of miles from Niagara, putting her surplus power to work, but as the years roll on and the growth of our population creates increasing demands for the peculiar products of Niagara's particular genius, we shall see this energy distribution gradually being drawn in. And creeping after it we shall see great steam plants slowly but steadily approaching Niagara, replacing in the homes and secondary industries that energy which, as time goes on, can less and less be spared from the home industries that will continue to grow around Niagara Falls.

EDITORIALS

Obsolescence of Power-Plant Equipment

OBSOLESCENCE of power-plant equipment is influenced by many factors other than efficiency, such as reliability, cost of maintenance and operation, space required per unit output and cost of installation, all of which affect the unit cost at the switchboard. With the advent of the steam turbine, highly superheated steam and more efficient methods of burning fuel, there came a period during the last twenty years when the rate of obsolescence of steam power-plant equipment was very high. In some cases the economic life of the engine or turbine did not exceed ten years, with fifteen years as about an average.

Where the best water rates of reciprocating engines were around fifteen and sixteen pounds per kilowatt-hour, by the use of high-pressure high-temperature steam expanding to a high vacuum the rate has gradually decreased in the steam turbine to between ten to eleven pounds. The sizes of units have increased from seventy-five hundred to seventy thousand kilowatts, and the space occupied per unit output has decreased anywhere from one-fifth to one-tenth of what it formerly was with the reciprocating steam engine. On peak loads it has become general practice to force boilers up to three hundred per cent of normal steaming capacity. In addition the size of the operating force has been considerably reduced. Although the last fifteen years of development has seen the maintenance cost run, in some cases, into formidable figures, many of the difficulties have been overcome and steam-power equipment is becoming highly reliable.

Probably among the best indications of this reliability are the record runs made by some large turbines, reaching as high as one hundred and fourteen days of continuous operation. Analyzing the foregoing factors indicates that, unless there is some radical departure in our present power-plant practice, the rate of obsolescence of modern steam power-plant equipment will be low, consequently great care should be exercised in its selection and installation.

In dealing with hydraulic power stations, an even more favorable condition is found. Where in 1900 the highest efficiency of the Francis turbine was around eighty-three per cent, and at half load sixty-three per cent, these units of modern design operate at efficiencies of over ninety per cent, between fifty and one hundred and ten per cent full load, with a maximum efficiency of ninety-three to ninety-four per cent. Reliability of hydraulic turbines has been developed to even a higher degree than in the steam turbine. There are hydraulic units that have a record run of thirty months' continuous operation to their credit. In a paper, "Hydraulic Development of Niagara Falls," by John Harper and J. A. Johnson, presented before the annual convention of the American Institute of Electrical Engineers, an abstract of which appears in this issue, the authors give some very interesting figures on the latest installation at Niagara Falls. Only two and one-half per cent of a total two hundred and twenty foot head is lost in getting the water to the penstock of the turbines, and of the total power available at the penstock entrance over ninety-one per cent is delivered at the generator terminals. In the operation of a plant containing three units of an aggregate capacity of one hundred thousand horsepower, only three men are required per shift.

These figures clearly indicate that, although the size of future units may be increased, where the size of the system upon which they operate may permit such increases, there is little opportunity to gain in efficiency or to reduce the cost of operation. Durability and reliability are the only two other factors that would operate to make these units obsolete, and from past experience with large hydraulic units they have proved to be not only reliable but also durable under favorable conditions. This condition makes the methods used in water-power development of paramount importance. If the most efficient designs are not now employed, at some future date there will be small reason for making a change other than the mistakes made in the original layout. The manufacturers have brought the hydraulic turbines up to a remarkably high degree of efficiency; it is now up to the hydroelectric power-plant engineer to develop our water power with an equally high efficiency.

Fighting Scale in Surface Condensers

IN REGIONS where water is scarce, cooling water for surface condensers must be used over and over again, in connection with cooling towers or spray ponds to dissipate the heat taken out of the exhaust steam in the condenser. In such systems the formation of a hard, heat-insulating scale, consisting mainly of calcium and magnesium carbonates, inside the condenser tubes is a source of continual trouble and loss—trouble, because it necessitates periodic cleaning of the condenser, and loss, not only through the expense of this operation, but also through the gradual decease in the operating efficiency of the steam unit, due to the increasing difficulty of holding the proper vacuum as the scale deposit grows. These conditions rapidly become so severe that the unit must be shut down and the condenser cleaned.

Two articles are published in this issue, dealing with this subject from two different viewpoints. One, by Norman G. Hardy, chief mechanical engineer of the Arizona Copper Company, Limited, of Clifton, Arizona, treats of the cleaning of condensers. The author gives the comparative costs of the mechanical method, which makes use of power-driven rotary cutters, and the hydrochloric-acid washing process, in which the scale is disintegrated by washing with dilute hydrochloric acid.

The second article is an abstract of a paper published in the February 12 issue of *Le Génie Civil*. It describes a Franco-Belgian process, somewhat facetiously bap-

tized by its inventor as the "vaccination" of cooling water. In this process the formation of scale is prevented by the continuous addition of hydrochloric acid to the cooling water makeup, in sufficient quantity to decompose all the carbonates and bicarbonates present into chlorides. Whereas the carbonates are almost insoluble, calcium and magnesium chlorides are so soluble that water holding them in solution may be boiled down, without precipitating the salts, until its density is twice that of aluminum. The degree of concentration of the circulating water may be set at any desired value by allowing a suitable proportion of cooling water to run to waste.

The advantages of this scheme are obvious—uniformly high efficiency of heat transfer in the condenser and a correspondingly low water rate in the unit, while shutdowns for cleaning will be almost if not entirely eliminated. There is one disadvantage—the cost. It is impossible to make a quantitative comparison of the relative costs of the continuous and periodic methods without accurate data as to the rate of scale formation with a specific quality of cooling water, the frequency of the necessary cleanings and the curve of efficiency loss of the unit during the interval between cleanings. However, a rough survey, using Mr. Hardy's data and supplementing them with divers assumptions, shows a practically prohibitive cost for the continuous treatment.

Assuming the total water rate of a 2,000-kilowatt unit to be eighteen pounds per kilowatt-hour, including all auxiliaries, the steam consumption for that unit will be about 36,000 pounds per hour. Assuming the evaporation in the cooling tower equal to the water rate and the cooling-water waste adjusted to one-quarter of the water rate, the total cooling-water makeup to be "vaccinated" will be approximately 45,000 pounds per hour. San Francisco River water, averaging one hundred and sixty parts of calcium carbonate and twelve parts of magnesium carbonate per million, would require about one hundred and twenty-eight parts of pure hydrochloric acid, or nearly five hundred and thirty-three parts of commercial hydrochloric per million, to completely decompose these salts. About twenty-four pounds of commercial hydrochloric per hour will therefore be required to treat 45,000 pounds of this water per hour. Assuming that there is sufficient storage capacity in the cooling-tower sump or the spray pond to take up the variations in the daily load, the makeup water need only be proportional to the average load. Assuming further a yearly load factor of fifty per cent, about 105,000 pounds of commercial hydrochloric will be required per year. At the extremely high price quoted by Mr. Hardy, this would cost more than $15,000 a year for a 2,000-kilowatt unit, which would more than pay for one condenser cleaning every five days by the hydrochloric-acid washing process. The "vaccination" process must, however, be credited with the gradual loss in efficiency in the steam unit between condenser cleanings. Assuming the extreme case of a unit whose water rate increases from eighteen pounds per kilowatt-hour when the condenser is clean to twenty-four pounds per kilowatt-hour just before it is subjected to another cleaning, the average water rate will have been increased about three pounds per kilowatt-hour, and the average waste of steam in a 2,000-kilowatt unit will be about 72,000 pounds per day with a fifty per cent load factor. This represents a waste of nearly 1,500 tons of coal per year. There have been times in the last four years when this might have turned the scales in favor of the continuous treatment.

If the so-called "vaccination" process is ever to have a chance, it can only be through the very high cost of coal and the very low cost of hydrochloric acid, and for large units. The price named by Mr. Hardy for commercial hydrochloric delivered at the plant includes about 85 per cent freight charge. Assuming that the plant was within easy reach of the chemical works, and in view of the large and continuous demand, an extreme low limit to the cost of the process under present market rates may be assumed to be fifteen per cent of $15,000, or $2,250 per year. If the cost of the total cleanings plus the cost of the coal wasted through impaired efficiency is greater than this figure plus the interest and depreciation on the "vaccination" equipment, this process would have some right to serious consideration.

A Chip on Its Shoulder

THE wholesale coal industry cites five reasons "why we fight" against the proposed coal legislation. These five reasons all exhibit a single underlying clause that, to most if not all impartial observers, would appear to be much like the chip on the shoulder of a red-headed lad.

"In forty-eight months," the wholesalers complain "we have not had forty-eight days in which we were free from attack," and, therefore, they say, "Yet, we are condemned because we have not worked out a program." Any group that carries a chip for as long as this is to be pitied. Their nerves certainly must be on edge. One can only stop and wonder what might have happened if they had ignored much of the legislative bunk which they have chosen to consider attack upon themselves and had gone about the business of really working out a program. Assuming that their program had been formulated in a reasonable sense of public service, we believe that they could have accomplished much more in self-defense by ignoring the attack and coming forward with sensible proposals.

To say that the coal business offers all the data that are wanted seems absurd when one recalls that practically every conservative effort recognized by law or business as fair has been tried to stop the Government from gathering figures even on a voluntary basis. And some say that the methods used have not always stopped with those regarded as legally fair.

The remaining three grounds for opposition to the pending coal bills are all based upon the assumption that these are going to be passed in a spirit of *"regulation"* of industry. Perhaps some of their proponents had in mind such a plan, but certainly most of the industrial community, including most coal users, have not supported this thought.

What is needed is a complete, prompt, regular summary of essential facts. Again we emphasize that if the wholesalers are afraid of such facts, it is well that some of our national legislators have become sufficiently suspicious of the industry to demand investigation and legislation. Indeed, if the present effort to oppose the gathering of facts continues longer, many who have stood out as opposed to regulation may be convinced that regulation is after all the only solution of the problem. Certainly, he who is so loud in his own defense even before a charge is made usually justifies an investigation as to propriety of making a charge.

CORRESPONDENCE

Going It Blind

In the March 8 issue of *Power*, page 375, R. T. Strohm, in verse, laments about the "Mossback," Jim Jimson, and in describing the plant notes the absence of instruments, meters, etc., and that Jim "goes it blind" from choice.

Jim is not the only one who goes it blind. Yours truly is in the same fix, but not from choice; and, while instruments are a necessity in modern engineering and the plant owner who does not provide them is blind to his own interests, yet I believe that a great deal can be done without them, as I will try to show.

When I took charge of my present plant, I found the eight boilers badly scaled. No instruments were necessary to prove that such a condition was wrong, and the boilers were cleaned. Four of them were coal-fired and four used wood refuse. The coal furnaces were too shallow and the boilers about 27 to 30 in. from the grates. The boiler fronts were so low that the ashpit doors could not be closed, and some had been broken off in the effort. I raised the fronts five or six inches, not to permit of closing the ashpit doors, because I do not believe they should be used to regulate the fires, but to enable the firemen to see into the furnace more easily. I also raised the boilers to 48 in. above the grates. The wood burners were really gas producers, the furnaces being only imitations of wood-burning furnaces, the firing being done in such a way that immense quantities of carbon monoxide were produced, which was continually catching fire in the breeching; flame is said to have been seen coming from the top of the chimney.

By instructing the firemen regarding combustion, with special emphasis on the air requirements, especially when burning shavings, and instituting the ribbon method of firing coal, along with tuning up the engine, we were able to effect a saving last year estimated at $14,000. There was a closed feed-water heater, which heated the feed water to 145 deg. F. and wasted the water of condensation. This was changed for an open heater, which gave a higher feed-water temperature. Oil separators were installed and the radiators were equipped with traps, the condensation from them having previously gone to the sewer. A vacuum pump was also installed and the condensation returned to the heater. The heating system, which was really and truly antique, was equipped in divers places with live-steam boosters under the control of anybody and everybody. To attempt to control them properly was unthinkable, so I left them alone the first year and then had new supply mains run wherever necessary and the boosters cut out. Although there is now more heating (a new building was added), the indications at present are that the saving this year will amount to $25,000; this does not include labor.

If you ask me what our rate of evaporation is, I will have to admit that I do not know. We have quotations on water meters and we also know where scales are built, but we have no meter. They cost so much, and while scales are useful throughout the factory, we cannot get them for the power plant; so we go it blind.

If you ask me about the quality of the flue gas, I must again answer, I do not know. We have a laboratory equipped with everything necessary in connection with manufacturing processes and even for making germ-culture tests in the first-aid department, but to enable me to produce power more cheaply, or more intelligently, there is nothing doing; we go it blind.

Can Mr. Strohm court the muse and see if she has any balm for those of us who are compelled to get along with what we have?

R. McLAREN.

Toronto, Canada.

Railroad Stationary Engineering

After reading Mr. Palmer's criticisms, on page 667 of the April 26 issue, and J. F. Coen's answer, page 793 of the May 17 issue, I agree with Mr. Coen. Mr. Palmer does not state by what railroad he was employed or at what point, his main theme being the inefficiency of the railroad man. Of course, it is well known that there are many bad points in the national agreements and that there are many inefficient men working under them, just as one will find in industrial plants, as a great many of the inefficient men were formerly considered efficient while working in industrial plants before coming to the railroad.

It seems to me that there was something wrong beside the inefficiency of the men in the shop. I am afraid that when Mr. Palmer first entered the plant as chief, he endeavored to misunderstand instead of understand the railroad man. He speaks of bucking the "committee"; then, farther on, he leads one to believe that he was bucking the management and supervision as well as the committee, as he has the same opinion of all.

He states that he arrived at the power plant about 9 a.m. and that the men had been waiting for him since 7 a.m. An experienced railroad man, knowing that there was important work to be done, would have been on the job at 7 a.m., especially if he had the least idea that the men who would be there were inexperienced in

power-plant work. There is a right way and a wrong way to handle men, and I believe Mr. Palmer used the wrong way.

I know that many boilermakers, while very efficient on locomotive work will "fall down flat" on power-plant work, and the same can be said of the other crafts as well. I also know some industrial engineers who have made good in railroad power plants that are considered the hardest on the system to handle. I also know some that have "fallen down" in some of the easiest plants on the system.

It requires railroad experience to operate successfully any part of a railroad. A man gains experience on the railroad by dealing square with other railroad men.

S. O. BENJAMIN.

Baltimore, Md.

Effect of Compression on Fuel Consumption

Referring to the article entitled "The Effect of Compression on Fuel Consumption," in the June 7, 1921, issue of *Power*, and to Fig. 1 of that article, since the thermal efficiency of the Otto cycle is

$$Efficiency = 1 - \frac{Temp.\ at\ O}{Temp.\ at\ E}$$

it is evident that an increase in the temperature at E, at the end of compression, such as would result from a higher compression, would increase the efficiency and therefore lower the fuel consumption per horsepower.

C. H. FESSENDEN.

Ann Arbor, Mich. University of Michigan.

[The foregoing statement is quite correct and agrees with the discussion in the June 7 issue, when pressures and volumes were used in place of temperatures and the reasons why the compression ratio determined the efficiency were explained.—Editor.]

How Can Air-Compressor Valves Be Prevented from Breaking?

In the May 10 issue of *Power*, page 756, B. E. Eckard asks how to prevent air-compressor valves from breaking. If, instead of having the valves lift and drop, they

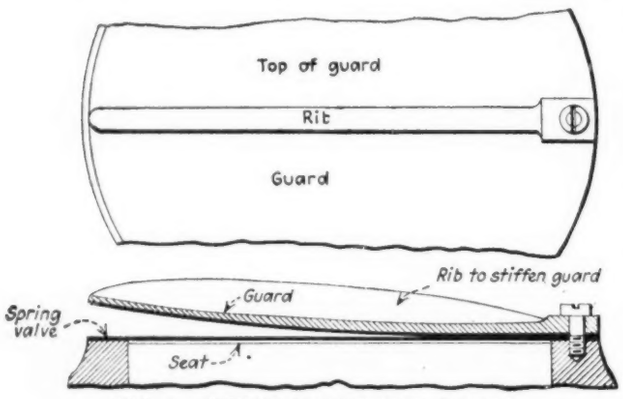


FIG. 1. SPRING VALVE AND GUARD

were made of a thin spring metal, held fast at one side and allowed to have a sort of heel-and-toe movement, there is no limit to the speed at which they could be operated. A guard should be attached to the top of the valve to keep it from opening too far and also to hold the end of the valve, as shown in Fig. 1.

Larger valves, as shown in Fig. 2, may be made in another way, and Mr. Eckard might try the idea on his compressor with satisfactory results. These valves

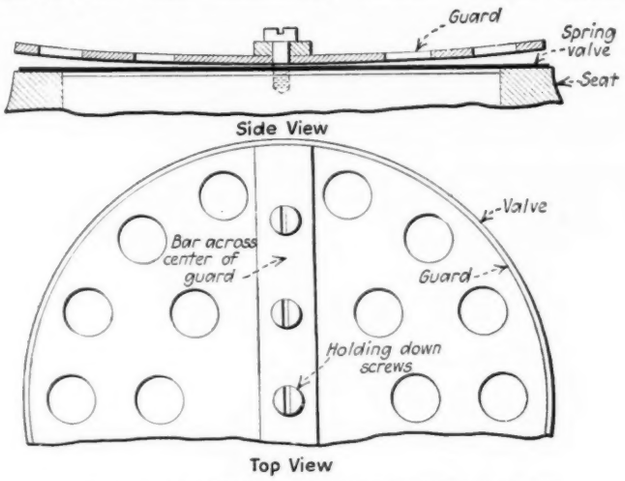


FIG. 2. ANOTHER TYPE OF SPRING VALVE

would have a rise and fall and would give ample opening for air-compressor service and ought to give no trouble. The guard would be of cast brass and the valve of spring steel or other suitable metal that is pliable. New seats could be put in with smaller openings to match the valves. I have used this style of valve on a 20-in. diameter rubber-valved air pump.

JOHN REDMOND.

New York City.

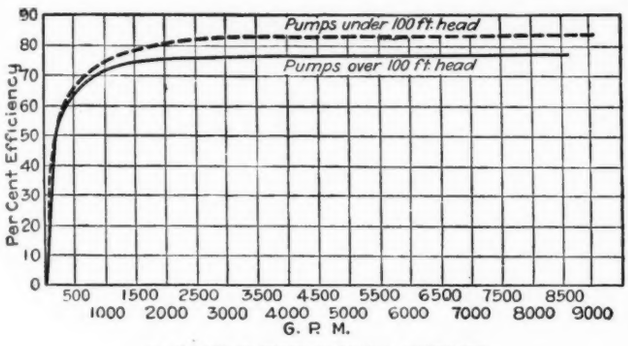
Classification and Efficiencies of Centrifugal Pumps

In the issue of *Power*, May 17, 1921, an article appeared by W. D. Canan on "Centrifugal Pumps—Part II. Dependency of Efficiency Upon Type, Size and Speed." The following statement is made: "In the high-lift class pumps, the speeds range from 400 r.p.m. to 3,000 r.p.m., the capacities 75 gal. per min. to 4,200 gal. per min. and the heads from 101 to 1,800 ft. In the low lift pumps speeds range from 133 to 2,500 r.p.m., the capacities 100 gal. per min. to 5,200 gal. per min. and the heads from 17 to 100 ft." It is the writer's opinion that the foregoing statements refer only to pumps from which the author received his information. It is obvious that the head capacity and speed limitations, as pointed out, are by no means general. The terms "high-lift and low-lift" as applied to pumps are understood to refer usually to the suction lift rather than the total head. The writer is of the opinion that Mr. Canan has referred to the total head against which the pump operates when he differentiates between high- and low-lift pumps. It should also be noted that, generally speaking, pumps operating against a total head of 50 ft. or more are classified as high-head pumps, or, using the author's notation, as high-lift pumps.

It is stated that there are three methods used in calculating the total head against which a pump operates. For ordinary commercial tests it is sometimes sufficiently accurate to use the first method; that is, to take the sum of the suction and discharge heads corrected to the center line of the pump. The second method, adding to the head as found in the first case the velocity head of the discharge line, is correct only if the velocity head in the suction line, at the point

where the suction pressure is being observed, is zero. The third method, as described by the author, is the most exact for ordinary tests.

In Fig. 1 Mr. Canan shows a curve plotted with gal. per min. as abscissas and per cent efficiency as ordinates. The dotted curve shows efficiencies which seem rather ambiguous, and both curves point out an average range of this high efficiency far greater than ordinarily found. Since the curves represent an average of some 73 tests, it stands to reason that some of the effi-



CAPACITY-EFFICIENCY CURVES

ciencies are even higher than the maximum as indicated by the curve, and this seems too high.

In conclusion the author states that the percentage of the maximum efficiencies that will be realized at fractional and overloads will be approximately the same for all pumps regardless of type, size or head. It has been the writer's experience that the efficiency characteristic depends entirely upon the type and design of pump and cannot very well be generalized by saying that regardless of type, size or head the efficiencies at fractional loads will be about the same for all pumps.

Lester, Pa. F. W. RABE.

Parallel Operation of Compound Generators

Near the top of page 460, second column, in the article, "Parallel Operation of Compound Generators," by A. M. Bennett, in *Power* of March 22, it is stated that the usual arrangement is as shown in the figure. This certainly is not correct for the part of the country where the writer lives. Out here the common practice is a three-pole switch with a common handle.

At this point in the article it would have been well to introduce the statement that whenever a plant starts out with a single compound generator, hence needing no equalizer, the main switch on the board will have but two poles. Later on, if another machine be added, it is often found that instead of installing a new three-pole switch for the old generator, a single-pole switch is merely added for the equalizer wire. It ought then to be carefully explained that the plan of wiring shown in Fig. 1 of the article should be used, instead of placing the single-pole switch in the equalizer. This wrong plan is generally used in such cases because it requires less changing in the switchboard wiring. The wrong plan has been common in this locality. I have known of several cases in plants of which I have had charge, in which the operating engineer carelessly threw in the two-pole switch without closing the single-pole equalizer switch and caused the incoming generator to be seriously damaged.

About the middle of the second column on page 460 it is recommended to "close the double-pole switch first." This is a serious mistake. The single-pole switch should be closed first. By closing the two-pole switch first, the incoming machine's series-field coils are at once placed in multiple with the series coils of the other machines and thus are robbed of a portion of their current, causing a drop in busbar voltage. If this drop is corrected before closing the single-pole switch, then the voltage will at once rise too high as soon as the single-pole switch is closed, because the taking on of a portion of the load by the incoming armature will reduce the armature voltage drop of the other machines.

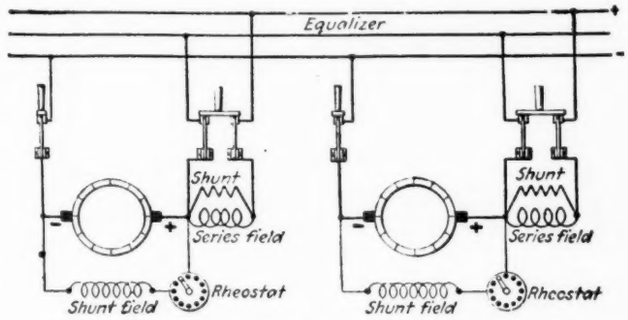
The proper way is to close the single-pole switch first. Then nothing at all happens until the two-pole switch is closed. The incoming generator then at once takes on its share of the load and its series-field coils get their proper share of the current, both at the same time, with no voltage disturbance on the system.

Kansas City, Mo. JAMES M. KENT.

[The foregoing letter was submitted to A. M. Bennett, author of the article in question, and the following is his reply.—Editor.]

Mr. Kent's questions in reference to the arrangement and closing of switches on compound-wound direct-current generators operating in parallel can best be answered together. I had assumed that it was almost universally known that the usual practice was, as I have shown; namely, a double-pole and a single switch. I have looked up a number of available references and find that this is recommended practice of the General Electric Co.; also the "Standard Handbook for Electrical Engineers," edition of 1915, pp. 631-32, and "Electric Lighting," Vol. 1., by F. B. Crocker, edition of 1908, show this arrangement.

With reference to the sequence in which the double-pole and single-pole switches are closed, I do not believe that closing the double-pole switch first is as serious a mistake as Mr. Kent indicates. The Standard



CONNECTIONS FOR OPERATING TWO TWO-WIRE COMPOUND GENERATORS IN PARALLEL

Handbook and Professor Crocker in his work, both recommend the procedure or sequence that I have advised, completing the act of connecting the generator to the busbars by closing the single-pole switch last. No doubt other authorities may be found recommending the same procedure, but these are the only two I have that mention the subject. Another reason for equalizing the machines before paralleling is that it affords a means of correcting reversed polarity or of being certain that polarity is correct.

Granting that a drop in busbar voltage is caused by first equalizing, and putting the series fields of the incoming machine in parallel with those of the other machines, as claimed by Mr. Kent, this drop should not be corrected as he seems to think is done. In my article, where I speak of adjusting the voltage after closing the double-pole switch, reference is had to the voltage of the incoming machine and not the line voltage. If the series fields of the working machine have been robbed of a part of their current, thus reducing their compounding effect, this is compensated for by decreased armature reaction, and voltage drop in the armature of the working machine, as soon as the incoming generator has relieved it of a part of its load. There is no doubt that it would have been well to call attention to the fact that the single-pole switch should not be placed in the equalizer line. While the arrangement is permissible, it is poor practice, and there is the possibility that the incoming generator may be damaged at the time of starting up, provided the equalizer switch is not closed first. A. M. BENNETT.

Erie, Pa.

[Since there seems to be a difference of opinion as to what is the best practice to follow when placing compound-wound generators in parallel, an expression of opinion on the subject by *Power* readers would be helpful to operating engineers.—Editor.]

Aligning Engine and Generator Shafts

In the May 3 issue of *Power* L. Harvey asks for a way to align his two engines and their generator. Both engines and the generator should first be placed on their foundations over their respective anchor bolts, which we will assume have been left free at the top end, so as to allow the engines and the generator to be shifted slightly for aligning.

Some long iron wedges, tapering from about one-half inch to one inch in one foot of length, should be inserted under the frame and the latter wedged up so as to allow for about three-quarters of an inch of grouting.

A very fine wire may now be stretched up, level with the center line of the engine shaft, as close to the center line as is convenient and parallel with the center line of the foundation. In order to get the wire up as close to the shaft as possible, it should be passed between the spokes in the flywheel and between the polepieces of the generator.

The portion of the shaft that carries the flywheel and the generator may now be lined up to this wire, by tramming and shifting the bearing pedestals until the tram will barely touch the wire and the shaft at each end.

To level this portion of the shaft, suspend a plumb bob near the side of the flywheel and near the shaft; then tram or caliper from the plumb-bob line to the side of the flywheel rim at the top and the bottom. One end of the shaft should be raised or lowered as required, until the distance from the rim to the line is exactly the same at both top and bottom. (This is assuming that the flywheel is machined on the side of the rim.)

The nuts on the foundation bolts in the two bearing pedestals should now be tightened to prevent any chance of getting out of alignment again. This being accomplished, one of the engines should be moved until the flange on the crankshaft faces up to the corresponding flange on the generator shaft, the flanges clearing each other by only a few thousandths of an inch. It can now be brought into approximate alignment by tramming from the shaft to the wire as in the aligning of the generator shaft. The engine may now be raised or lowered until a spirit level will test absolutely level when placed across the two halves of the coupling.

A small try-square may be placed across the back side of the coupling on the generator shaft, allowing the blade to stick out across the edges of both flanges and tried all the way around, shifting the engine until the blade of the square will touch the edges of both halves of the coupling all the way across. This will put the engine in fairly close alignment, and it would probably run this way.

A feeler gage should now be used between the coupling flanges, and, if necessary, the engine should be shifted so that the space between the flanges is the same at all points. The other engine may be aligned in like manner, and when all is ready the grouting may be run under. EARL PAGETT.

Cherryvale, Kan.

Boilermakers as Inspectors

The article "Boilermakers as Inspectors," page 714 of the May 3 issue, was of considerable interest to me, since I have for a number of years been acquainted with many inspectors who came from boiler shops. Mr. Palmer's contention that boiler-shop work does not particularly fit a man for the position of boiler inspector is undoubtedly true. However, many of the very best boiler inspectors with whom I have been acquainted received their training in a boiler shop.

In regard to boilermakers not being able to figure the safe working pressure on return-tubular boilers, this is, as a rule, true, but I am sure it would not be a good plan for these men to become as expert as Mr. Palmer assumes himself to be in making such calculations.

The construction of butt-strap joints as shown in his illustration is very unusual. Generally, the ends of the outer straps have the corners cut off, but where a strap with square ends, as illustrated, is used, the four rivets, two of which are marked "new," would usually be applied. The rivets in the end of the strap are, of course, parallel with the girth seam joining the two courses of the boiler and closely adjacent to this seam, and since Mr. Palmer is gifted enough in the matter of calculating the strength of the shell of a boiler to determine the difference that might be made by the application of these so-called "new" rivets, he is certainly doing the engineering profession an injustice by keeping this information to himself.

It is my opinion that there would be no difference in the strength of the shell whether these "new" rivets were applied or omitted, as undoubtedly, should such a shell be subjected to a pressure that would destroy the seam, it would fail at some point away from the girth seams rather than where these new rivets are located.

It would be interesting to know if Mr. Palmer could tell what effect the placing of a 4 x 6-in. handhole in the center of a course of a boiler, such as referred to in his article, would have on its strength. It would seem that this problem was simpler than the one he has solved in regard to the effect of the application of the "new" rivets, but so far I do not know of an engineer who has felt himself capable of solving it. J. E. TERMAN.

New York City.

INQUIRIES OF GENERAL INTEREST

Leading Side of Duplex Pump—Which is the leading side of a duplex steam pump? G. R.

The side having the long rocker arm is the leading side. Where the rocker arms are of equal length, that which has a crank attached pointing in the same direction is the leading side.

Solder for Squirrel-Cage Rotor Bars—What should be the composition of solder for use in soldering the bars and end-rings in a squirrel-cage induction-motor rotor? F. M. H.

One formula frequently used for this purpose is 50 per cent copper and 50 per cent zinc. It should be carefully noted, however, that this is for use with a torch, for the alloy should have a considerable proportion of its zinc content burned out of it during the process of brazing, else it will be too hard and brittle.

Slippage of Boiler-Feed Pump—Can a boiler-feed pump deliver more water to the boiler than the amount represented by the piston or plunger displacement of the pump? R. E. N.

Discharge of a pump in excess of the piston displacement, or negative slip, is not likely to occur unless there is a long suction pipe and a long-stroke pump, with discharge taking place against a comparatively low pressure that can be overcome by the ram-like action of the suction water. These conditions are rarely if ever present in boiler operation, and usually there is positive slippage of the feed pump.

Loosening of Piston Rod Jamb-Nut at Crosshead—Our engine has a 3-in. piston rod that is screwed into the crosshead with a jam-nut. Having had trouble in keeping the jam-nut tight, a machinist beveled off the bearing face of the nut, taking off about $\frac{1}{32}$ in. towards one side, and gave as a reason that the nut worked loose because the fit of the threads was too perfect. Is this good practice? E. B.

Beveling the bearing face of the jam-nut causes a bending stress in the rod and is not good practice. Screwed rods become loose, more than from any other reason, because the rods do not work in line, and generally from improper adjustment of the crosshead shoes. If a jam-nut works loose with good alignment of the crosshead and even bearing of the jam-nut, slacken off the nut and turn the rod over a few degrees to give new points for bearings of the screw threads in both crosshead and jam-nut.

Saving from Using Buckwheat with Soft Coal—Our present monthly consumption of soft coal, used exclusively, is 140 net tons (2,000 lb.) costing $5.93 per ton. What would be the saving per month if, instead of burning only soft coal, a mixture is used consisting of two-thirds soft coal and one-third buckwheat coal? The price of the buckwheat coal is $4.51 per gross ton (2,240 lb.) and it is assumed that it requires 15 per cent less soft coal than buckwheat to do the same amount of work. C. D. E.

The cost per pound of soft coal is $5.93 ÷ 2,000 = $0.002965, and the cost per pound of the buckwheat coal would be $4.51 ÷ 2,240 = $0.0020134. As it requires 15 per cent less soft coal than buckwheat to do the same work, a pound of buckwheat would be equivalent to 1 — 0.15 = 0.85 lb. of soft coal. Each pound of a mixture consisting of $\frac{2}{3}$ soft coal and $\frac{1}{3}$ buckwheat would take the place of

$$\frac{2}{3} + \frac{0.85}{3} = 0.95 \text{ lb. of soft coal,}$$

that would cost $\frac{2}{3}$ of $0.002965 + $\frac{1}{3}$ of $0.0020134 = $0.0026477, and the cost of replacing each pound of exclusively soft coal would be $0.0026477 ÷ 0.95 = $0.0027870. Hence the saving by use of the mixture in place of all soft coal would be

$$\frac{\$0.002965 - 0.002787}{\$0.002965} \times 100 = 6 \text{ per cent;}$$

and the saving, based on the present rate of consumption and cost for soft coal, would be 6 per cent of 140 × $5.93 = $49.81 per month.

Superheat in Ammonia-Compressor Suction—What are the disadvantages, if any, of having the ammonia-suction gas come to the compressor in a superheated condition? F. H.

The sole purpose of the compressor in a refrigerating plant is to compress the ammonia gas to a pressure somewhat above the saturation pressure corresponding to the condenser-coil temperature. If the pressure is above the saturation of boiling pressure, the ammonia will condense when it is cooled to the condenser temperature. In compressing the gas, work is done and the gas will heat. If the gas comes to the compressor in a dry, saturated condition, the compression superheats it and the heat to be removed by the condenser is

$$H_1 - h_2 + (t_3 - t_2)\,S = Q$$

where

Q = Heat to be removed;

H_1 = Total heat of saturated ammonia at the condenser pressure;

h_1 = Heat of the liquid at the condenser pressure;

t_3 = Temperature of the ammonia discharge;

t_2 = Temperature corresponding to the condenser pressure;

S = Specific heat of superheated ammonia.

The heat added by the compressor work is $Q_1 = H_1 - H_2 + (T_3 - T_2)\,S$, where H_2 is the total heat of the saturated ammonia vapor entering the compressor. The smaller the amount of discharge superheat the lower the work of compression becomes.

Assume a case where the ammonia comes to the compressor in a dry saturated condition with a suction pressure of 30 lb. absolute and leaves the compressor with a discharge pressure of 120 lb. absolute. If no heat other than the work of compression takes place in the cylinder, the discharge gases will have a temperature of 160 deg., including 90 deg. of superheat. The work of compression per pound of ammonia handled by the compressor is 88 B.t.u. This is obtained easier from a Mollier diagram than by calculation, since the specific heat of ammonia is not a constant. On the other hand, if the suction gas comes to the compressor superheated 20 deg., the work of compression is 125 B.t.u. The work is increased, while the compressor capacity is decreased owing to the greater volume per pound of the superheated suction gas. The cooling necessary in the condenser in the case of saturated suction and superheated discharge is less than that required when the ammonia comes to the compressor in a superheated condition.

Development and Applications of the Hydraucone Regainer*

By W. M. White

The new method of regaining pressure from velocity of fluids in motion consists in causing the stream flow to impinge upon some definite shape, either flat, conical or concave, thus changing its direction, and then placing an envelope around the shape so formed upon the particular base used, which envelope conforms to the shape of the fluid at entrance and gradually recedes from what would be the normal or free shape of the non-inclosed fluid impinging upon the particular base used; the effect of this gradually diverging envelope being to change the velocity head of fluids flowing at high velocity into its entrance into pressure and low velocity at its exit. The angle of divergence of the envelope from the normal or free shape of the impinging fluid is such as to bring about the same phenomena of flow conditions as result in an expanding straight-axis tube such as the discharge end of a venturi meter. The new method therefore provides a means for transforming velocity head into pressure head within a short distance measured along the axis of the inflowing stream, and has useful application in water-power plants, supplanting the usual curved draft tube and providing for higher efficiencies with a minimum of excavation. For clearness reference is only made in this discussion to the single-Francis-runner vertical waterwheel unless otherwise stated.

The draft tube of a waterwheel serves two purposes. The first of these is to maintain at the discharge side of the runner passages a suction action equivalent to the difference in elevation between the runner and the level of the tail water, thereby providing for the use of the total head. The second purpose is to transform the velocity head in the water as it is discharged from the runner into pressure

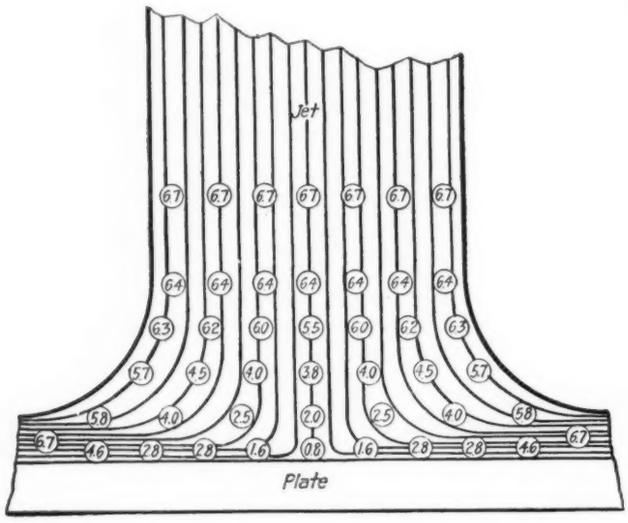


FIG. 1. HYDRAUCONE ACTION OF WATER JET IMPINGING NORMALLY ON FLAT PLATE

head by the time the water reaches the end of the draft tube, and thus maintain at the discharge side of the runner passages a suction action greater than that which would be caused by the difference in elevation between the runner and the level of the tail water.

At first thought it seems like attempting to lift oneself with one's bootstraps to endeavor to utilize the energy in water after it has left the waterwheel runner, but this utilization may be effected by an efficient transformation of the velocity head in the water discharged from the runner into pressure head, which causes an increased suction action at the runner and thus maintains a greater head acting on the runner than the total head as measured between the equivalent water level of the water at entrance to the waterwheel and the level of the water in the tailrace.

The necessity for an efficient means for regaining pressure from velocity of the water discharged from the waterwheel runner in modern power plants has been brought about by the ever-increasing demand for higher speeds of waterwheels for given conditions of power and head. The cost of electric generators of such sizes and speeds as are usually

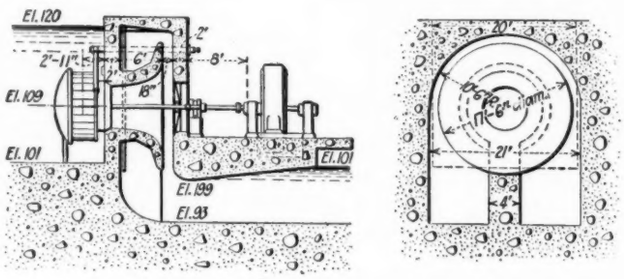


FIG. 2. HYDRAUCONE REGAINER WITH HORIZONTAL-SHAFT WATERWHEEL

employed in water-power plants varies inversely as the speed, hence the buyer maintains a constant urge for higher waterwheel speeds, to meet which many high-speed types of runners have been brought out. As the specific speed of a runner increases, the percentage of energy it discharges also increases. A runner of moderate specific speed discharges water with such velocity that the energy contained in the water as velocity head is about 10 per cent of the energy of the total head; and runners of highest specific speeds discharge the water at such velocity that the energy contained in it as velocity head is from 20 per cent to 25 per cent of the energy due to the total head acting on the waterwheel. In order to secure high efficiency with high-speed runners, it is therefore vital to regain the major portion of the energy contained in the water discharged from the runner for useful effect upon the waterwheel, for as more of the energy which is discharged from the runner is regained, the efficiency of the water-power plant is increased.

By the term "hydraucone action" of water is meant that action which occurs when an uninclosed stream impinges against and is deflected along a surface. Fig. 1 illustrates the hydraucone action of water when a jet impinges normally upon a flat plate. In considering the three outer stream filaments, it was noted and recorded in 1900 that the cross-sectional area of the flow increased in making the turn and decreased at the exit from the turn. By placing a cone on the plate with its axis in line with the center line of the jet, the outer shape of the curvature of the water is changed, but not to a great extent because of the low velocities within the center portion of the impinging jet.

The lines in this figure represent the stream lines of flow of the water, which were traced by injecting a small stream of blue water into the jet at various points along a diameter and noting and recording the flow line. The plate used in this case was of glass so as to afford ample light for making the observations. The figures in the circles are the velocities in feet per second at the various locations indicated. It will be noted that the water at the center of the jet slows up as it reaches the plate and deliver its velocity head into pressure head at the center of the plate. This pressure head at the center is transformed into velocity as this stream flow passes from the center of the point of impingement to the point beyond the radius of curvature. Referring to Fig. 1, the radius of curvature of the water in making its change in direction is definite and it is the minimum that can be used in regaining devices and yet obtain the reactions within the point of impingement which will give smooth stream flow of discharge along the plate and consequently without eddies and attendant losses.

*Abstract of a paper presented before the American Society of Mechanical Engineers at the Spring Meeting, Chicago, May, 1921.

[Mr. White describes at length an exhaustive series of tests to determine the most efficient shape of limiting envelope, one deduction being that the hydraucone regainer with flat plate gives better efficiency than with cone center, as the friction along the surface of the latter is much greater than when the water forms its own cone.—Editor.]

FIELD OF APPLICATION OF THE HYDRAUCONE REGAINER

The field of application of the hydraucone regainer will be greater on low-head plants, although it is now being installed in connection with two 40,000-hp. units that are to operate under a head of 421 ft. Hydraucone regainers are in operation or in course of construction in twenty-five hydro-electric power plants. These hydraucone regainers are to operate under heads varying from 8 ft. to 421 ft. and with waterwheels developing from 150 to 40,000 hp.

An interesting installation is that at the plant of the Cheboygan Electric Light and Power Co., Cheboygan, Mich., shown in Fig. 2, where a hydraucone regainer was used with a waterwheel having a horizontal shaft. The hydraucone passages were placed vertically. The top of the hydraucone chamber is nearly 19 ft. above the level of the water in the tailrace, but no difficulty has been experienced in the effective operation of the hydraucone regainer in this position. Others of this type are now in course of construction.

Everyone familiar with hydro-electric power-house operation where curved draft tubes are employed has frequently noticed the boiling and disturbance of the water at the outlet from the curved tubes. This disturbance is clearly an evidence of inefficiency and loss of energy which should be more effectively utilized. The hydraucone regainer provides a means for efficiently regaining the energy discharged from the runner for useful effect upon the waterwheel within the limited space available in the power-house foundations.

District Heating Engineers Meet

Breakers Hotel, Cedar Point, Ohio, from June 22 to 24, was headquarters for the twelfth annual convention of the National District Heating Association. A full program, a registration of approximately one hundred, and unusual facilities for entertainment, all combined to make the gathering a decided success. President J. L. Hecht was in the chair and in his address at the opening session spoke to the text of "Public Relations." In the past public utilities had been so busy building up their systems that little attention had been given to educating the people as to their needs and to creating the friendly attitude necessary for fair treatment. A decided change in policy had taken place. From now on education would be regarded as a primary function. When the people understood the merits of the case and that their interests rose and fell with those of the public utility, trust could be placed in their judgment to refute the destructive suggestions of the political demagogue.

Secretary Gaskill reported a total membership of 305, which represented a gain of 3 during the last year. S. Morgan Bushnell showed that insurance rates were lowered 4 to 5 per cent by district heating, due to the elimination of furnaces and other sources of fire. This saving amounted to the same thing as a reduction in the rate for steam and so interested the association that a committee was appointed to investigate and gather data on this subject. Steam as an asset in putting out fires was also a factor considered.

Next was the report of the Public Policy Committee, which covered two subjects: "Abandonment of Plants and the Causes' and "Commission Findings on Rates and Service." In the following summary is pointed out the lessons to be gained from the records of the discontinued plants.

1. Heating systems must be located in municipal districts, that by the density of buildings will assure the greatest amount of radiation possible per foot of line.

2. Small cities and towns are deficient in such territory and should be carefully considered before locating, to determine if adequate business per foot of main can be obtained.

3. That a strictly heating business unaccompanied by any electric business is not to be desired, as the heating business is a business getter for the electric and must be credited with its value in this phase of central-station operation.

4. That depreciation must be recorded and not allowed to accumulate until the cost of removal and replacement is prohibitive.

5. That no system should be installed that does not permit of measured service, so that the company will be paid for the heat units that it supplies.

Mention was made of the more favorable attitude of commissions and courts in granting adequate rates, so that as a result the industry is on a sounder basis and is receiving better returns for service rendered than in pre-war days. To offset the increased heating rates, the association passed a resolution calling for the appointment of a committee to enlighten the public in the possible ways of reducing their steam consumption and thus lowering their bills.

WEDNESDAY AFTERNOON SESSION

At the afternoon session James A. Donnelly presented the report of the Heating Research Committee, reviewing briefly what had been done at the Research Laboratory at Pittsburgh, calling attention to a standard method of testing heating systems on which the American Society of Heating and Ventilating Engineers is now working and suggesting a number of things that might be done by the association, such as the preparation of a theoretical diagram showing the heat loss through walls of different construction, which would also bring out the increment necessary to care for wind velocity and the effect of heat from the sun. Such a chart would furnish a means of arriving at an approximate estimation of requirements and show at what times the greatest losses occurred. In the discussion it was suggested that an investigation be made of the effect of using superheated steam on the distribution losses. Being a poorer conductor of heat than saturated steam, the loss from radiation and consequently the condensation should be less. It was pointed out that there was danger of high-pressure superheated steam charring or actually setting on fire the wood log, although this might be obviated by keeping the temperature below 300 deg. F.

The report of the Meters and Accessories Committee, read by R. C. March, gave connections for condensation meters and accessory equipment that had been tried out and found satisfactory, as a step towards standardization. The report also traced the development of heat control and described various types of thermostats and regulators.

THURSDAY MORNING SESSION

At the Thursday morning session F. B. Orr presented the report of the Station Operating Committee, which was divided into eight sections dealing with recent developments relating to boiler plant operation, such as clinker grinding, extension grates, side air ducts, control panels and instruments; boiler pitting and corrosion; blowdown methods; a questionnaire giving data from various companies regarding distribution and the quality of steam delivered, and a symposium on the later types of forced-draft chain-grate stokers for bituminous coal, which included performance data and manufacturers' descriptions. It was the opinion of the committee that the forced-draft idea would predominate henceforth as the economies and advantages far outweighed the obstacles to its adoption. The superior qualities credited to the stoker were increased economy and combustion efficiency over a large range of load, increased capacity and flexibility, ability to burn poor grades of coal and positive control of all conditions. Perhaps the most serious disadvantage of forced-draft operation was the slagging over of the bottom rows of tubes with a hard deposit, which in a short time closed up the passages and in bottling up the furnace tended to build up excessive temperatures, when attempting to sustain high capacity. Mechanical soot blowers had to be operated every few hours and their work supplemented by hand removal of the slag with rods and hooks introduced through openings in the side or front walls. Without these precautions the boilers would have to be let down frequently for a thorough cleaning; in some cases as often as once a week. Use of a type of

baffling that increased the area of the first pass and thereby reduced the velocity of the gases seemed to be quite essential.

Another difficulty was the presence of secondary combustion resulting in high uptake temperatures and disturbance of the water level. Careful adjustment of the air pressures would eliminate this condition. It was believed that the design of the links had a bearing upon the extent to which CO would be generated, certain portions of the grate permitting rapid air flow and quick combustion, while on other portions the coal burned out more slowly, throwing off CO gas, which remained in stratification until it passed over the front baffle into the second pass. Satisfactory and continuous operation was certain only when the fuel remained fairly uniform in size. Any great variation, such as lumps of coke braise in any quantity would mean a loss of the fire. The discussion turned to delayed combustion, ignition arches, the necessity for coal uniform in size, methods to prevent clinker adhering to the side wall, such as the use of carborundum brick, and the corrosion of return lines due to non-condensible gases. In the Joliet plant of the Public Service Company of Northern Illinois over 75 per cent of these troublesome gases had been removed by installing a closed heater and boiling the water with live steam.

H. D. Savage, of the Combustion Engineering Corporation, read a paper on the "Use of Pulverized Coal," mentioning results obtained particularly at the Oneida and the new Lakeside plants of the Milwaukee Electric Railway and Light Co. Tests had shown that much coarser coal than called for by the usual standard, in which 85 per cent would pass through a 200-mesh screen, could be burned successfully, also that coal running as high as 11 per cent in moisture had been burned without drying. With hollow furnace-wall construction through which the air for combustion passed and was preheated, the rediation loss ran about 100 B.t.u. per sq.ft. at rating and 125 B.t.u. at 200 per cent of rating.

Electrical Equipment in the Heating Plant

In an interesting paper J. C. Hobbs gave an outline of a method for determining in any particular case whether it would pay to install electric generating equipment in the heating plant. The items to be considered were tabulated, and in the paper these items were discussed in detail. The discussion following was prolonged. In St. Louis, where a number of small plants were concerned, it would not pay to use the heating steam for electric generation. In Peoria the installation of generators showed a handsome return on the investment. Detail comparisons were made from the standpoint of a city served by large condensing plants and heating plants at some distance from condenser cooling water. Advantages of high-pressure steam distribution were considered, and as a summary it was the consensus of opinion that each plant gave a distinctive problem which must be solved according to the conditions existing. There seemed to be a difference of opinion as to the credit that should be allowed for the current generated by the heating steam, a number contending that the full generating cost in the main station was too much, as labor, coal and other expenses were not reduced in proportion. The heating plant was entitled only to the increment charge which represented the saving effected in the large generating station.

A paper on the "Coal Situation as It Now Exists," read by C. F. Wahn, referred to the present indifference of buyers as being almost akin to the buyers' strike of 1919. The consumer was hesitating to buy coal until the miners' wages were deflated. The miners were under contract until March 31, 1922, and costs of production had so increased that a drop to pre-war prices was not to be expected, at least not this year. Mention was made of the difference in "spot" and contract prices, the latter being higher instead of the reverse, which was usual. A uniform demand was desirable from many angles, as it would allow the mines to be worked continuously, would eliminate the less efficient mines which had kept up the price, and by doing away with the holdover charge would bring the price per ton more nearly to the actual cost of production.

R. D. DeWolf, in a paper on "Non-Condensing Operation on Heating Loads," gave some interesting facts relative to the installation of a 750-kw. turbo-generator in one of the substations of the Rochester Gas and Electric Corporation for supplying low-pressure steam to one of its largest heating customers. The installation was described, steam rates of the turbine at different loads given and curves showing the kilowatt-hours generated per day for different outside temperatures. An automatic valve was installed in the main steam line to the turbine to maintain a constant back pressure, and the turbine governor was adjusted so that it would act only as an overspeed device, acting when the speed exceeded normal by 5 to 10 per cent.

In line with the company's policy on decentralized plants, other turbine installations are being considered, and to overcome the labor difficulty it is planned to keep the turbines in operation without attendance, but inspected from time to time. As the turbine unit is self-contained and either operates practically 100 per cent or becomes inoperative so that the average operator is unable to overcome the difficulties, such a plan of automatic operation is considered feasible, proper safeguards being used to protect the machine and a reducing valve being installed to bypass the turbine in case of shutdown. One man could inspect each turbine every two or three hours and thus by reducing the labor charge enhance the economic advantages of supplying low-pressure steam in this way.

L. J. Pauley, manager of the Guardian Building in Cleveland, gave the results of his experience with a single-pipe heating system hand-regulated and compared the results obtained in buildings of similar size, one with a two-pipe system and the other having a single-pipe system with thermostatic control. He arrived at the conclusion that the care given the equipment and intelligent operation had more to do with economy than the type of system. In the comparisons made carefully conducted hand regulation gave better results than thermostatic regulation, due to the opening of windows with the automatic control.

"Rates" was the subject of a committee report, and at the final session Friday morning there was a paper by R. A. Heitbrink, devoted to "Hot Water Rates," but also applicable to steam.

The Association's Handbook Nearing Completion

J. H. Walker, chairman of the Educational Committee, gave out the welcome intelligence that the "Handbook of the National District Heating Association" was nearing completion. It was a summary of valuable data that had been gleaned from the "Proceedings" and contained pages of technical information on manufacturers' products. The publication was a summary of the literature on district heating made up in loose-leaf form and of a size suitable to carry in the coat pocket. Subsequent sheets were to be supplied as made up, and manufacturers had the privilege of changing their data at the expense of the printing. The volume would make an excellent working handbook.

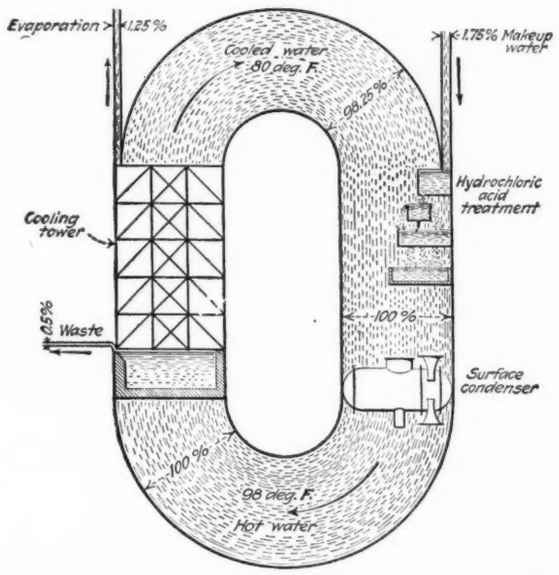
Walter J. Kline presented some observations on the management and service of district heating systems, and in the final paper of the convention, on "Central-Station Heat from the Viewpoint of the Office Building," E. S. Shultz presented, first the mental attitude of the average office building owner and of his architect, manager and engineer and their inaccurate estimates as to the relative advantages of central-station service versus operation of their own plants. In an appendix a system of power-plant accounting was presented, which, if generally adopted, would in the author's opinion do away with the difficulties the central-station steam companies now experienced, both in selling their output and in maintaining and justifying their rates.

With its excellent facilities for water sports and other amusements brought out in the entertainment features and the isolation insuring full attendance at the technical sessions, the selection for the next convention again fell to Cedar Point. The following officers were elected for the ensuing year: J. H. Walker, president; E. L. Wilder, first vice-president; F. B. Orr, second vice-president; D. S. Boyden, third vice-president; D. L. Gaskill, secretary-treasurer; J. L. Hecht, F. A. Tucker and Charles H. Day, executive committee.

Eliminating Scale Troubles in Closed Surface-Condenser Cooling Systems*

In closed cooling systems for surface condensers, in which the hot water from the condenser is cooled in a cooling tower or spray pond and sent back to the condenser to be used over and over again, there is a gradual concentration of the salts in solution in the cooling water. This is due to the fact that a certain quantity of pure water evaporates in the cooling tower or pond, leaving its salts in the system, whereas the makeup water that is added to replace this brings with it a certain quantity of solids in solution. Fresh salts are therefore continually being brought into the system and none are being removed, while the total volume of circulating water remains constant.

Most natural waters contain varying proportions of calcium and magnesium carbonates, bicarbonates and sulphates. The bicarbonates and sulphates are soluble and give little trouble as such. But the bicarbonates are unstable and break down under temperature and pressure changes into the carbonates that are almost insoluble, and are precipitated in the hottest parts of the condenser in the form of a hard scale. This has the double disadvantage of decreasing the cross-sectional area of the tubes and of forming a heat-insulating lining that interferes with the transfer of heat through the walls from the steam to the water. Thus the operating efficiency of the turbine is gradually impaired as the scale accumulates in the condenser. It must therefore be periodically removed, either by mechanical means or by washing with hydrochloric acid, at the cost of considerable delay, trouble and expense.



DIAGRAMMATIC REPRESENTATION OF CLOSED SURFACE-CONDENSER COOLING SYSTEM SHOWING THE PROCESS FOR THE ELIMINATION OF SCALE BY CONTINUOUS TREATMENT WITH HYDROCHLORIC ACID

The Scam-Balcke process, for the continuous treatment of circulating water with hydrochloric acid, also known as the "vaccination" of circulating water, consists in adding hydrochloric acid continuously to the makeup water in sufficient quantity to decompose the carbonates and bicarbonates into chlorides before they are allowed to enter the system. Calcium and magnesium chlorides are so soluble that the solution may be concentrated down to five times the density of pure water before the salts will crystallize out. The formula for the chemical reaction is as follows:

$$Mg\,CO_3\ (\text{or } CaCO_3) + 2\,HCl = Mg\,Cl_2\ (\text{or } Ca\,Cl_2) + H_2O + CO_2$$

Carbon dioxide is released as a gas by the reaction, forming a faint cloud that rapidly disappears from the circulating water.

The illustration is a diagrammatic representation of a closed cooling-water system using a cooling tower. The cooling-water temperature is high and the range low, which accounts for the large proportion of total cooling water for a given quantity of makeup water. The evaporation in this case is about 1.25 per cent of the total cooling water; assuming the evaporation in the cooling tower practically equal to the water rate of the turbine, this allows 80 lb. of cooling water per pound of steam condensed. Besides the water lost by evaporation, a small amount, in this case 0.5 per cent of the total, is purposely allowed to run to waste in order to keep down the concentration of the circulating water. The amount of waste may be arbitrarily chosen to give any degree of concentration of the circulating water. With the values assumed, the waste is $\frac{0.5}{1.75} = \frac{1}{2.86}$ of the total makeup water, and the concentration of the circulating water will remain constant when it reaches 2.86 times that of the makeup water. If water is scarce or expensive, the concentration may readily be increased to ten times that of the average makeup water without danger of precipitating the sulphates. In order to accomplish this, it will be necessary to waste an amount of cooling water about equal to one-ninth of the steam condensed, and supply ten-ninths for makeup water, or with the temperature conditions assumed in the diagram, waste 0.14 per cent and supply for makeup 1.39 per cent of the total cooling water.

It may be considered advisable to keep the dose of acid very slightly below that necessary to decompose all the carbonates, in order to avoid the presence of free acid in the water. Any carbonates remaining would break up into bicarbonates and remain soluble. However, there could be no harm in the presence of the very slight excess of acid necessary to completely change all the carbonates to chlorides.

In the Scam-Balcke process the acid is first diluted, then automatically mixed with the makeup water in the correct proportions in a series of tanks. The mixture is then allowed to run through a mixing tank with suitable trickling surfaces or baffles, which accomplish the double object of thoroughly mixing the acid with the water and of allowing the carbon-dioxide gas to escape. It is important that this should be removed, in order to avoid the accumulation of gaseous bubbles on the walls of the condenser tubes, as this would impair the heat transfer.

*Abstract of an article published in *Le Genie Civil*, Feb. 12, 1921, page 153.

Cost of Preparing Pulverized Coal

During 1920 the cost of preparing coal in the power plant of the Clarkdale Smelter was as follows:

Unloading, storing and reclaiming coal, per ton	$0.07
Conveying and primary crushing, per ton	0.09
Drying and disintegrating, per ton	0.30
Pulverizing	0.52
Total operating costs	$0.98

These figures include power, labor, supplies, repairs and plant expense, but do not include depreciation and other fixed charges. The installation costs of a pulverizing plant are as follows:

Storage and reclaiming plant, per ton storage capacity	$13.00
Primary crushing plant, per ton daily capacity	32.00
Drying and integrating plant, per ton, daily capacity	286.00
Pulverizing plant, per ton daily capacity	402.00

With a 300-ton plant the investment, with a seven-day storage plant, would be around $243,000; if interest, depreciation and taxes are assumed to equal 15 per cent, then the fixed charges per ton total $100 per day, or 33c. per ton. The entire pulverizing costs then become $1.31 per ton.

Prospecting for oil by airplane in the uncharted wilderness that constitutes the delta of the Orinoco is about to be carried out by a British oil company. It is considered that the presence of oil should easily be ascertained from the air, since where it comes to the surface vegetation cannot live.—*The Engineer, London.*

Public Utility Information Committees Being Organized

Arrangements have been completed for a committee on public utility information for the State of Georgia and plans are under way for a similar committee in Alabama. The Georgia committee will have its headquarters at 324 Healy Building, Atlanta, and its work will be carried on by L. K. Starr as executive secretary. Mr. Starr was previously assistant city editor of the *Atlanta Journal*.

All the large utilities of Georgia have shown an active interest in the movement and have pledged moral and financial support. The executive committee, which will direct the work, includes George T. Smith, Augusta-Aiken Railway and Electric Corporation, chairman; P. S. Arkwright, Georgia Railway and Power Co., vice chairman; C. D. Flanigan, Athens Gas Light and Fuel Co.; F. L. Marshall, Gas Light Co. of Augusta; H. C. Foss, Savannah Electric Co.; P. R. Bomeisler, Ware County Light and Power Co.; L. A. Magraw, Macon Railway and Light Co.; L. K. Starr, executive secretary.

George F. Oxley, director of publicity of the National Electric Light Association, and Labert St. Clair, of the American Electric Railway Association, met with members of the committee June 14 and 15 and assisted Mr. Starr in organizing and outlining his plans for conducting the work.

On Thursday, June 16, Mr. Oxley went to Montgomery and met with public-utility men interested in the organization of a similar committee for Alabama, and after some discussion it was definitely decided to organize an Alabama committee. S. B. Irelan, vice president and manager of the Montgomery Light and Water Power Co., will have active charge of the organization of the committee, and the director of the work was tentatively chosen subject to confirmation by the executive committee when it is finally organized. It is expected that the committee will be fully organized and headquarters will be opened in Montgomery not later than August 1.

While in the South Mr. Oxley also attended several sessions of the convention of the Associated Advertising Clubs of the World at Atlanta and conferred with officials of the association and with public-utility advertising representatives with a view to laying the groundwork during the next twelve months for the organization of a Public Utilities Advertising Section of the Associated Advertising Clubs of the World at its 1922 convention in Milwaukee.

Value of Mixtures of Coke Breeze and Bituminous Coal as Fuel for Hand-Fired Boiler

Bureau of Mines Paper No. 2244, written by John Blizard and James Neil, and published May, 1921, describes tests that were made to determine the value of a mixture of coke breeze and bituminous coal as a fuel for hand-fired heating boilers with particular reference to the method of operation, draft required and efficiency obtainable. The tests were made on a cast iron sectional boiler having the following characteristics:

Area of grate, sq.ft.	32.5
Width of air space in grate area, in.	¼
Proportion of air space in grate area, per cent	31
Area of heating surface, sq.ft.	815
Rated output, B.t.u. per hr.	3,780,000
Volume of mixing chamber, cu.ft.	20
Volume of combustion chamber, cu. ft.	36
Mean height from grate to roof of furnace, in.	32
Volume of furnace, cu.ft.	93

Although this boiler was considerably larger than those ordinarily used for heating houses, it is believed that the general results of the tests would apply to the latter.

The fuel used was a mixture containing equal parts of Pittsburgh run-of-mine coal and coke breeze from byproduct coke ovens. Tests were made using both coarse and fine breeze. The average calorific value was about 12,900 B.t.u. per lb. for the coal and 970 B.t.u. per lb. for the coke breeze.

In these tests the mixture of Pittsburgh coal and coarse coke breeze gave less than one-half the smoke given out by the coal alone, about 20 per cent less steam, and required a stronger draft. The steaming value of the coarse breeze was about 70 per cent of that of the coal, so that to compete with the latter, allowing for the possible necessity of using steam jets to give the required draft, it should cost less than 70 per cent as much.

At a low rate of steaming, the mixture with the fine coke breeze showed practically the same efficiency and draft as that with the coarse. However, the draft required rose very rapidly and efficiency fell considerably at increased loads, while the amount of smoke produced became considerably greater than for the coarse breeze. For these reasons the fine breeze is recommended only for use at low rates of combustion.

American Boiler Manufacturers Association

The Thirty-third Annual Convention of the American Boiler Manufacturers' Association at Bedford Springs, Pa., June 20-22, brought together a goodly representation of the leading boiler manufacturers of the country.

The meeting was opened on Monday morning by the presentation of an able address by the retiring president, A. D. Schofield, dealing with conditions in the industry. E. R. Fish, who represents the association in the Uniform Boiler Law Society, reported as to the relations of the two bodies, and Charles E. Gorton, chairman of the U. B. L. S. gave a detailed report of the work of the society in preserving unity among the states that have already adopted boiler legislation and in urging others to do so.

Joseph F. Scott, president, and C. O. Myers, secretary, of the National Board of Boiler and Pressure Vessel Inspectors, discussed the proposed work of that body with especial relation to the simplification of data sheets, the stamping of boilers, etc.

The report of the secretary-treasurer, H. N. Covell, showed a small gain in membership and a satisfactory financial condition.

On Monday evening Judge William H. Speer, of New Jersey, gave an interesting talk on "Current Menaces to Industry," and Mr. Richardson, of the Midvale Steel and Ordnance Co., exhibited an interesting set of slides and films showing the processes involved in the making of steel boiler plate and tubing from the gathering of the ore to the inspection and testing of the finished product.

On Tuesday morning E. R. Fish reported as the representative of the Association on the Boiler Code Committee of the American Society of Mechanical Engineers. S. F. Jeter, chief engineer of the Hartford Steam Boiler Inspection and Insurance Co., explained the situation with regard to tolerances, which has been giving members of the A. B. M. A. some concern. A subcommittee, of which C. S. Blake, president of the H. S. B. I. & I. Co. is chairman, has been appointed by the Boiler Code Committee to consider the question of Rules for Inspection. One of the questions involved was the allowances or tolerances that an inspector may make in enforcing the Code, and there developed such a difference of opinion that a questionnaire had been sent out to boiler manufacturers and others soliciting their views. It was this circular that had aroused the apprehensions of the members. In order to assure the association that nothing was to be done without their knowledge and co-operation as well as to avail itself of their expert knowledge, the committee asked the association to suggest some of its members to be added to the subcommittee, and Starr H. Barnum, F. G. Cox and Lawrence Connelly were named for that purpose. It was further explained that there would be ample opportunity to see and discuss the report of the subcommittee before it was adopted by the main committee and that it would have to be approved by the Council, published and be the subject of a public hearing before it could become a part of the Code.

The discussion of a proposition that the safe working pressure of all commercial boilers be computed upon a tensile

strength of 55,000 lb. was deferred until the fall meeting.

H. L. Parks, chief draftsman of Arthur G. McKee & Co., Cleveland, read a paper on the "Proper Method of Filing and Numbering Drawings."

Reports were received and discussed from A. G. Pratt on Related Industries, and upon Stokers. A Joint Conference Committee consisting of representatives from the A. B. M. A. and from the Stoker Manufacturers' Association has organized with A. G. Pratt as chairman and John Van Brunt, secretary, and the committee had adopted a report for the consideration of the two societies, embodying agreements as to points of common interest and as to the part of the work and expense of the combined unit to be assumed by the boiler or stoker manufacturer. One item of general interest is the setting height for the different types of boilers as follows:

Water Tube, Horizontal; Floor line to bottom of header above stoker.
Water Tube, Inclined; Horizontal mud drum; floor line to center of mud drum.
Vertical mud drum; floor line to top of mud drum.
Water Tube, Vertical; Horizontal mud drum; floor line to center of mud drum.
Vertical mud drum; floor line to top of mud drum.
Horizontal Return-Tubular; Floor line to under side of shell.

The following table shows Minimum and Preferred Minimum setting heights unanimously agreed upon by all members of the Joint Committee:

	Taylor Westinghouse Riley Jones A.C. Type E				Jones Single Retort		Murphy Detroit		Roney		Chain Grate — Natural Draft		Chain Grate — Forced Draft	
	Min.	P.M.	Min.	P.M.	Min.	P.M.	Min.	P.M.	Min.	P.M.	Min.	P.M.	Min.	P.M.
Water tube, horizontal	10	12	10	12	8	10	8	11	8	10	10	12	12	14
Inclined (hor.m.d.)	7	8	6	8	6	8	5	7	6	8	6	8	7	8
Inclined (ver.m.d.)	5	6	5	6	3'6	5	3'6	5	3'6	5	3'6	5	6	8
Vertical (hor.m.d.)	3	4	3	4	3	4	3	4	3	4	3	4	3	4
Vertical (ver.m.d.)—150 hp	4'6	5	4'6	5	4'6	5	3'3	..	3'6	4'6	4'1	4'7	5	5'6
250 hp	5'6	6	5'6	6	5'6	6	3'3	..	3'6	4'6	4'1	4'7	5	5'6
500 hp	6	6'6	6	6'6	6	6'6	3'3	..	3'6	4'6	4'1	4'7	6	6'6
H.R.T. 72-in	8	10	8	10	7	10	7	8	6	8	7	8	8	10
84-in	8	10	8	10	7	10	8	9	6	8	7	8	8	10

Committee reports were also received and discussed from G. S. Barnum, on Cost Accounting; A. D. Schofield, on Ethics; W. C. Connelly, on Commercial Relations, and H. N. Covell, on Membership.

On Wednesday morning F. R. Low, editor of *Power*, outlined some of the "Duties and Possibilities of a National Board of Boiler Inspectors."

A discussion on the effect of oil engines and central-station service upon the use of boilers brought out the opinion that a lesser number of boilers will be built, especially of the smaller sizes; that the building of boilers will become more and more of an engineering problem, and that more stress will be placed upon quality and service. "The f.o.b. shop proposition is dead."

The allowable thickness of plates in horizontal return tubular boilers was asked for. Mr. Jeter said that the practice of the H. S. B. I. & I Co. for design and specification has been $\frac{5}{8}$ in. although they insure some $\frac{3}{4}$ and $\frac{7}{8}$. They usually have trouble with anything over $\frac{5}{8}$. Planing down the joints helps some. The consulting engineer is insane upon the subject of making the horizontal return-tubular boiler thick.

Mr. Barnum asked if the trouble was in the girth seams and was told that it was usually, although there was an occasional damaged plate.

Mr. Fisher thought it was not so much a question of manufacture as of operation. With good water, good circulation and moderate firing there should be no trouble with thick sheets.

The election of officers resulted in the unanimous choice of the following: President, A. G. Pratt, Babcock & Wilcox Co., New York; vice-presidents, G. S. Barnum, The Bigelow Co., New Haven, Conn.; H. N. Covell, Lidgerwood Mfg. Co., Brooklyn, N. Y., secretary-treasurer. Executive Committee: F. C. Burton, Erie City Iron Works, Erie, Pa.; E. C. Fisher, Wickes Boiler Co., Saginaw, Mich.; C. V. Kellogg, Kellogg-MacKay Co., Chicago, Ill.; W. S. Cameron, Frost Mfg. Co.; Galesburg, Ill.; W. A. Drake, The Brownell Co., Dayton, Ohio; Alex. R. Goldie, Goldie & McCullock Co., Galt, Ont., Canada; F. G. Cox, Edge Moor Iron Co., Edge Moor, Del.; J. C. McKeown, John O'Brien Works Co., St. Louis, Mo.

Two John Fritz Medals Awarded

A group of prominent engineers sailed for England recently to take part in awarding the 1921 and 1922 John Fritz medals to an Englishman and a Frenchman. The 1922 medal is being awarded ahead of the usual time, it is explained, "because of the desire of the American engineers to make the dual event the occasion of international ceremonies which shall mark the beginning of a closer engineering union of countries allied in war."

The 1921 medal is presented to Sir Robert Hadfield, of England, for his contribution to science in the development of manganese steel. The formal presentation was scheduled for the opening meeting of the British Institution of Civil Engineers in London on June 29. Other important meetings will be held in London, in which the American engineers are expected to participate.

On July 8 the committee will go to Paris to present the 1922 medal to Eugene Schneider, French engineer and scientist and head of the famous Creusot Steel Works. There will be a formal celebration at which greetings will be extended to La Societe des Ingenieurs Civils de France. According to the cablegram notifying Mr. Schneider of the award, the medal is to be given him "for achievement in metallurgy of iron and steel; for development of ordnance, especially the 75-mm. gun, and for notable patriotic contribution to the winning of the war."

The members of the mission are as follows: Ambrose Swasey, of Cleveland, founder of Engineering Foundation, past president of the American Society of Mechanical Engineers and general chairman of the deputation; William Kelly, of Vulcan, Mich.; John R. Freeman, of New York; Charles F. Rand, of New York; Charles T. Main, of Boston; Robert A. Cummings, of Pittsburgh; D. C. Henny, of Portland, Ore.; William Kelly, of Vulcan, Mich.; Major General George O. Squier, U. S. A.; Prof. A. E. Kennelly, of Harvard; Frank B. Jewett, of New York; Jesse Merrick Smith, of New York; Dr. Ira N. Hollis, of Worcester, Mass., and Col. Arthur S. Dwight, of Columbia University, who represents the Federated American Engineering Societies. The other members of the mission represent the four Founder Societies.

An Employees' Training Course in a Power Plant

In order to bridge the gap between the theoretical training given in schools and the practical work of a power plant, the Southern Sierras Power Co., according to the *Journal of Electricity and Western Industry*, offers its employees a practical course of training designed to supplement their high-school or college education.

An important phase of the course is that it aims to give a thorough general knowledge of all branches of the business as well as specialized knowledge of one particular department. In this way each man learns the relation between his work and the rest of the business.

There are two different courses—a two-year senior course for those who hold the equivalent of a bachelor degree from a recognized college or university, and a three-year junior course for high-school graduates or those who are otherwise qualified to handle the work. A starting salary of $80 per month for the senior students and $50 for the juniors is paid; these rates are increased every six months, and at the end of the course depend on the student's ability. The courses include work in the auditing, commercial, en-

gineering, executive, operating, purchasing and treasury departments.

The following paragraph is quoted from a pamphlet prepared by the company to describe its attitude toward the course and its method of carrying on the work.

In this course, while the students "learn by doing," the idea of training is kept uppermost in mind and is never subordinated to mere utilization of the students' services. Students are all given the same general training through the greater part of their course, but toward the end are given special training in the particular department or class of work for which they show most aptitude and ability. They are paid a sufficient compensation to cover living expenses, this compensation gradually increasing, at fixed intervals during their training period. Students completing the course are given a Students' Training Course Certificate and the company obligates itself to give such students a position in the permanent organization at a reasonable and substantial salary.

A Start Toward a New Steam Table

On Thursday, June 23, at the instigation of George A. Orrok, a number of those interested in the perfection and unification of the tables of the physical properties of steam met at Pierce Hall, Harvard University, and after a day's discussion of the discrepancies in the present tables and the data upon which they are based, arrived at the following conclusions:

We, the undersigned, having met in informal conference in Cambridge, Massachusetts, on June 23, 1921, have discussed at some length the present situation with respect to steam tables in the United States.

We feel strongly that it is of great importance to all users of steam in the United States that the properties of steam should be known with reasonable accuracy at pressures considerably higher than those at which any reliable experimental data are at present available.

After canvassing the situation, we believe the following experimental program should be undertaken:

1. The specific heat of water should be determined with the greatest possible accuracy up to the boiling point of water at atmospheric pressure for the more accurate determination of the mechanical equivalent of the mean heat unit. The specific heat of water should also be determined at higher temperatures for the better determination of the heat of the liquid.

We believe that this work can best be done at the United States Bureau of Standards.

2. The pressure-temperature-volume relation of superheated steam should be determined experimentally at high pressures and over as wide a range of superheats as possible.

We believe that this work can best be done at the Massachusetts Institute of Technology under the direction of Professor Frederick G. Keyes.

3. The density of liquid water should be redetermined accurately over a wide temperature range above that at which satisfactory data are now available.

We believe that this work can best be done at the Massachusetts Institute of Technology under the direction of Professor Frederick G. Keyes. We understand that in this connection Professor Keyes will be able to check the vapor-pressure curve of Holborn and Bauman.

4. The Joule-Thomson cooling effect in superheated steam should be determined at pressures to 600 lb. and at temperatures up to 600 deg. Fahrenheit.

We believe that this work can best be done at the Harvard Engineering School under the direction of Professor Harvey N. Davis.

5. Independent measurements of the specific heat at constant pressure of superheated steam should be made at higher pressures than those covered by the Munich experiments as a check on the volume and Joule-Thomson measurements. This work should be undertaken at the earliest possible moment. At present no one seems willing to undertake this work.

We believe that it could best be done at the United States Bureau of Standards and that they should be requested to undertake it as soon as other conflicting work can be finished.

We estimate that this program could be undertaken at a cost of about $35,000 a year, and we hope that it could be completed in about three years.

We earnestly recommend that the American Society of Mechanical Engineers undertake the furtherance of this research program through its research committee and that the society undertake to receive and administer the necessary funds. We wish to recommend this program to the favorable consideration of the various interests concerned with the use of steam and to request their financial cooperation in making its realization possible.

GEO. A. ORROK	HARVEY N. DAVIS
F. R. LOW	EDWIN H. BROWN
ARTHUR M. GREENE, JR.	ROBERT C. ALLEN
ROBERT C. H. HECK	ERNEST L. ROBINSON
LIONEL S. MARKS	H. C. DICKINSON
FREDERICK G. KEYES	EDGAR BUCKINGHAM
G. A. GOODENOUGH per R. C. H. HECK	E. F. MUELLER
	C. E. DAVIES

Not present but concurring

C. A. ADAMS	CHAS. H. SMOOT
D. S. JACOBUS	I. E. MOULTROP

Obituary

T. E. Gatehouse, for nearly forty years editor and part proprietor of the *Electrical Review*, London, died recently at the age of 67. He was well known in England, as the paper that he directed is among the leading technical journals of that country. He was a member of the Institution of Civil Engineers, of the Institution of Electrical Engineers and a fellow of the Royal Society of Engineers.

Personals

Chester H. Loveland, who has served as a hydraulic engineer for the last seven years with the California Railroad Commission, has opened consulting engineering offices in the Merchants Exchange, San Francisco.

Friend P. Williams has been appointed secretary of the New York State Water-Power Commission, which was established by the last session of the legislature to investigate the state's water power. Mr. Williams was formerly special deputy state engineer of New York.

Prof. C. A. Adams has decided to resign as chairman of the Division of Engineering of the National Research Council in order that he may return to Cambridge, Mass., and devote his entire time to his work as professor of electrical engineering at the Harvard Engineering School.

Dr. Philip Woodworth, executive secretary of the National Council of Defense, has been chosen president of the Rose Polytechnic Institute, Terre Haute, Ind. At various time he has been connected with the Peoples Gas Light and Coke Co., the Chicago Surface Line, the Chicago Elevated Railway, the Chicago Telephone Co., and the Commonwealth Edison Co., as a consulting engineer. He is the author of several books, including "Engineering Principles."

Society Affairs

The Ohio State Association of the National Association of Stationary Engineers, at the closing session of its twenty-fourth annual convention held June 18 at Cincinnati, elected the following officers; President, R. V. Demary, Akron; vice president, J. D. Alspach, Columbus; secretary, George Kasgye, Cleveland; treasurer, T. S. Garrett, Dayton. Cleveland was selected as the next meeting place.

Business Items

The Metal and Thermit Corp., 120 Broadway, New York City, has transferred William Aldrich from the Southern to the Western territory and William H. Moore from the Chicago to the Southern district.

Louis and Watts is an engineering firm recently organized by R. L. Watts and H. H. Louis for the purpose of conducting a general power-plant engineering and sales business in Seattle, Wash.; Vancouver, B. C.; and Portland, Ore.

The Westinghouse Electric and Manufacturing Co. has appointed N. G. Simonds manager of the Chicago office in place of T. Julian McGill. Mr. Simonds was previously manager of the industrial division of the Chicago office and has been with the Westinghouse company for over nineteen years.

The Link-Belt Co., 910 South Michigan Ave., Chicago, has acquired all the capital stock of the H. W. Caldwell Son Co. and Frank C. Caldwell has been elected a director of the Link-Belt Co. The Caldwell plant, however, will continue to operate under separate corporate existence and under its present name.

Gibbons & Brown, a firm of consulting engineers specializing on power plants and industrial problems, has been formed by J. O. G. Gibbons, formerly with Westinghouse Church Kerr & Co. and more recently in private practice, and C. E. Brown, for several years a United States ordnance engineer. The new firm's offices are in the Ordway Building, Newark, N. J.

Trade Catalogs

The Atlas Valve Co., 282 South St., Newark, N. J., is distributing a new bulletin, "Victor Damper Regulator No. 3." The device described is designed for boiler pressures up to 250 lb.

The Allis-Chalmers Manufacturing Co., Milwaukee, Wis., has put out a new bulletin on its line of small steam engine-driven electric generating sets for isolated lighting and power plants, exciter units, construction work, etc. The units are rated at from 2½ to 27½ kw.

Condensed-Clipping Index of Equipment

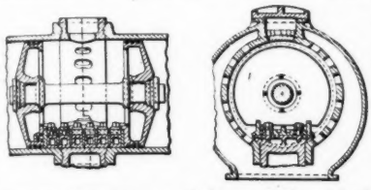
Patented Aug. 20, 1918

Piston, Unaflow Engine

The Engineer, (London).

"Power," 1921.

This piston comprises two separate movable sections or ends, mounted on the piston rod, the steam pressure being taken up against flanges on the rod, and the two sections being held against the flanges by means of nut and screw threads. The weight of the piston is carried by a sliding bearing set between the piston ends. In the larger types this bearing will be separated into several compartments by means of transverse flanges, each compartment to contain a sliding block with a spring to keep it pressed against the inner face of the cylinder. Springs may also be provided longitudinally to keep the bearing blocks pressed against the ends. These springs are interchangeable and may be used for any length of piston or bearing.

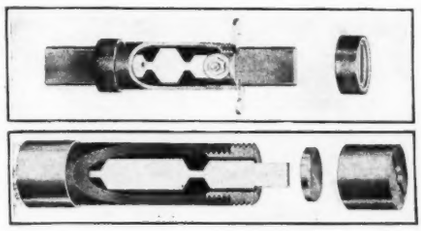


Fuse, Monarch Refillable

Monarch Refillable Fuse Co., Jamestown, N. Y.

"Power," 1921.

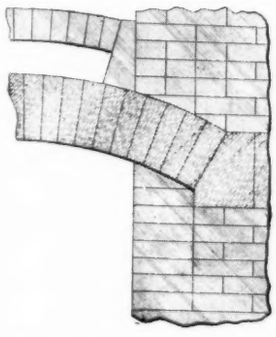
A refillable fuse consisting of a fiber shell into which is threaded metal ends, to which the end ferrules screw on and hold the fuse element. This fuse construction is such that the ends of the shell can be opened when replacing a new fuse element. In the cartridge type the ends of the fuse element are held between the ferrules and the removable metal disks on the end of the shell; in the blade type the fuse element is bolted to the knife terminals and then placed in the shell. This fuse has been approved by the Underwriters Laboratories.



Arch, Carr Ventilated Furnace

Elmer E. Carr, 3826 Hermitage Ave., Chicago, Ill.

"Power," 1921.



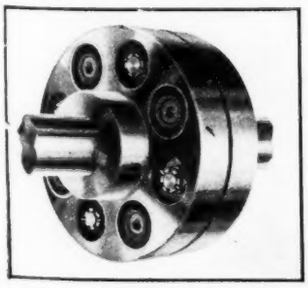
This furnace arch is made up of specially designed refractory material consisting of a standard skewback block of special shape, a feather-edge liner, large and small 10-in. straight blocks and wedge blocks of the same depth, the small block being half the width of the large one. With these blocks furnaces of several different widths, 6 to 12 ft. inclusive, can be equipped with ventilated arches. No iron, steel or other material is used. Air is admitted into a space between the arches at any convenient point in the boiler setting and is drawn into the furnace by the stack draft through the openings in the combustion arch. The air cools the arch, and in turn it is heated before being introduced into the furnace.

Coupling, "Ajax" Flexible

Ajax Flexible Coupling Co., Westfield, N. J.

"Power," 1921.

The "Ajax" shaft coupling is made of two flanges into which are fitted hardened steel studs. The studs project alternately from one flange to the other, entering oilless bronze bearings. Flexibility is obtained by a member consisting of a brass sleeve into which is compressed Para rubber surrounding a bronze bearing. The studs have free endwise movement through the bearing. All parts are interchangeable.

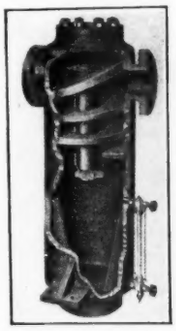


The coupling can be put on the shaft assembled, or if space does not permit, the studs can be driven into position and the nuts tightened after the flanges are in place. The coupling permits the connected shafts to float freely in their own centers, compensate for endwise movement together with angularity. The coupling is insulated, which makes it desirable on electric drives.

Separator, New Stratton

The Griscom-Russell Co., 90 West Street, New York City.

"Power," 1921.



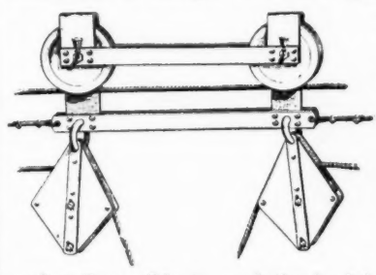
This separator is a redesign of the old Stratton separator. The helical path has been lengthened in order to increase the centrifugal separating action, and this feature, together with the spatter cap on the outlet pipe, increases the separating efficiency. When used for steam, the lengthened helical path removes water from the steam at all velocities. It is also used for air, for removing the water before the air enters the tools or machines in which it is to be used. It is made of cast iron and cast steel. The former is made in sizes of from 1¼ to 2 in. inclusive for 250 lb. working pressure and from 2½ in. to 8 in. inclusive for 200 lb. working pressure. All cast-steel sizes are for 250 lb. pressure.

Conveyor, Universal Coal

Universal Conveyor Co., South Bend, Ind.

"Power," April 12, 1921.

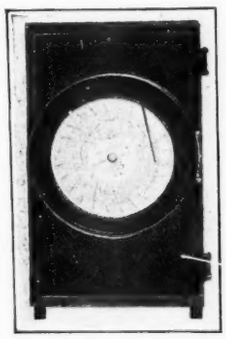
This system handles coal from railway cars to overhead bunkers or to storage. It is of a tower-supported trolley design and handles 500 lb. of coal at a time, requiring one man to operate it. It has a capacity of from 50 to 60 tons in 2½ to 3 hours. A jacknife gate at the bottom of the chute, operated by the man at the hoist, allows the coal to flow into the bucket or stops the flow when the bucket is out of the pit. The bucket is self-filling, self-dumping and self-righting. The system largely centers on two drum hoists. A reversible traction drum makes it possible to send the load in either direction from the hoisting tower. The hoist has a lifting speed of 100 ft. per min. and a traction speed of 200 ft. per min.



Recorder, Republic CO_2

Republic Flow Meters Co., Chicago, Ill.

"Power," April 24, 1921.

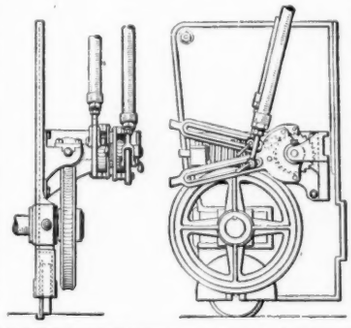


This instrument has been recently improved. The chart and recording mechanism are secured to the cover, and the analyzing units are arranged in a case. Glassware has been replaced by copper pipettes and tubing. Samples are analyzed at definite and fixed intervals, and the CO_2 percentages are recorded by a continuous line on a chart. The operation of the instrument depends upon the flow of water supplemented by proper floats, vents, seals and specially designed siphons which remove the water after analysis has been made to permit a repetition of the cycle. A continuous sample of gas from the furnace is drawn by means of a water jet and aspirator. This water is collected in a vertical container within the case, and its rise and fall automatically measures the gas, forces it through a potash solution, measures the residue gas and registers the loss in volume from the absorption of the CO_2.

Stoker, United Chain Grate

United Stoker Co., Hammond, Ind.

Power, April 26, 1921



This stoker has a flexible, double drive giving practically uniform motion to the grate. Longitudinal tracks form the upper and lower run and counterweighted dampers are arranged to shut off the rear portion of the grate area. There is also a special feed gate and ignition arch. Each driving link is supported by two track rollers on which the pins are riveted to prevent the rollers from coming off. Due to the construction, the sole function of the grate is to support the fuel bed. The air openings in the grate are made at an angle to the vertical which prevents sifting of coal through them.

Clip, paste on 3 x 5-in. cards and file as desired

FUEL PRICES

BITUMINOUS COAL

The following table shows the trend of the spot steam market in various coals (mine-run basis, f.o.b. mines):

Coal	Market Quoting	June 21 1921	June 28 1921
Pool 1,	New York	$3.45	$3.00@3.35
Pocahontas,	Columbus	3.40	3.50@3.60
Clearfield,	Boston	2.25	1.85@2.50
Somerset,	Boston	2.10	1.75@2.15
Pittsburgh,	Pittsburgh	1.85	1.75@1.90
Kanawha,	Columbus	2.15	2.00@2.35
Hocking,	Columbus	2.15	2.00@2.20
Pittsburgh No.8	Cleveland	2.10	2.00@2.15
Franklin, Ill.,	Chicago	2.90	2.25@3.50
Central, Ill.,	Chicago	2.40	2.00@2.75
Ind. 4th vein,	Chicago	2.50	2.25@2.75
Standard,	St. Louis	1.75	1.75
West Ky.,	Louisville	2.00	1.75@2.25
Big Seam,	Birmingham	2.50	2.25@2.75
S. E. Ky.,	Louisville	2.25	2.00@2.50

New York—On June 28, Port Arthur light oil, 23@25 deg. Baumé, 4¼c. per gal. 30@35 deg., 6c. per gal. f.o.b. Bayonne, N. Y.

Chicago—June 25, for 24@28 deg. Baumé, 35@45c. per bbl.; 32@34 deg. 1¼@1¾c. per gal. in tank cars f.o.b. Oklahoma refinery, or freight adjusted.

St. Louis—June 25, prices f.o.b. cars, tank lots; 24@26 deg. Baumé, 40c. per bbl.; 26@28 deg., 45c.; 28@30 deg. 50c.; 32@34 deg. 1¾c. per gal.

Pittsburgh—On June 20, f.o.b. refinery; Pennsylvania, 36@40 deg., 3¾c. per gal.; Oklahoma, 24@30 deg. 35c. per bbl., gas oil, 32@34 deg., 1¾c. per gal., 36@38 deg., 2¼c. 38@40 deg. 2¾c.

Philadelphia—On June 20, 26@28 deg., Baumé, Oklahoma, 3¼c. per gal.; 30@34 deg., Oklahoma (group 3) 2¾c. per gal.

Cincinnati — June 27, for 22@28 deg. Baumé, 6¼c. per gal.

Cleveland — June 27, for 22@28 deg. Baumé, 5c. per gal.

New Construction

PROPOSED WORK

Mass., Springfield — The Chicopee Natl. Bank, 460 Main St., plans to build a 10 story bank and office building on Main and Sanford Sts. About $700,000. Architect not yet selected.

Mass., Springfield — The Masonic Hall Assn., 115 State St., plans to build a 5 story, 133 x 275 ft. Masonic Temple on State St. About $1,000,000. McClintock & Craig, 33 Lyman St., Archts.

Mass., Worcester — Holy Cross College, College St., will soon award the contract for a 4 story college building here. About $300,000. Maginnis & Walsh, 100 Boylston St., Boston, Mass., Archts.

Conn., Ansonia—The Ansonia O. & C. Co., 153 Main St., will soon award the contract for a 1 story boiler house. About $25,000. Lockwood Greene & Co., 101 Park Ave., New York City, Archt. and Engr.

N. Y., Attica—The Bd. of Trustees will receive bids until July 11 for improvements to its water-works, consisting of piping, pump well, pump house, pumping equipment distributing reservoir, etc. Noted March 29.

N. Y., New York (Manhattan Boro.)—Saks & Co., Bway & 33d St., plans to build a 9 story department store, 5th Ave., and 50th St. About $2,000,000. Starrett & Van Vleck, 9 East 40th St., Engrs.

Pa., Reading—The city will receive bids until July 13 for

Three 250 hp. water tube boilers.

Two 160 hp. water tube boilers and reconstruction of 4 existing boilers.

Three 250 hp. automatic chain grate stokers.

Six 160 hp. automatic chain grate stokers.

One 750 hp. feed water heater.

One 800 G.P.H. water purifier with alternative proposition on one 2,400 G.P.H. unit.

Two 11, 250 C.F.M. fans and engines with alternative proposition on three 5,625 C. F. M. units.

One radial brick chimney.

Coal and ash handling equipment.

One 15 M.G. centrifugal pump, condenser and auxiliaries.

Pa., South Fork—The South Fork School Dist., 224 Maple St., will soon award the contract furnishing a steam boiler, pipe, radiators and all necessary apparatus for heating South Fork School. E. L. Roberts, Pres.

Va., Wytheville—R. P. Johnson is in the market for a Duplex steam pump with 4 in. suction and 3 in. discharge, 50-kw., 250 volt, d.c. generator; direct connected engine and complete equipment. (Good, used.)

Fla., Arcadia—The Tropics Products Co. is in the market for a 50 hp. boiler and a 25 hp. engine. J. R. Payne, Secy.

La., New Orleans—The Sewerage Water Bd. has received bids and will soon award the contract for furnishing, delivering and erecting a 200 hp. fuel oil engine. A. Earl, Supt. Bd. Noted June 7.

O., Cleveland—The Grand Area of the Fraternal Order of Eagles, 2226 East 55th St., plans to build a 3 story club house. About $500,000. John W. Reynolds, Clk. Architects not yet selected.

O., Cleveland — The Catholic Charities Corp., c/o Wm. F. Lyon, Century Bldg., plans to build a boys' orphanage, including a power house, on State Road near Bran Road. About $300,000. Architect not selected.

O., Cleveland—The Forest City Athletic Club, c/o Fred L. Brockman, Chn., 6523 Euclid Ave., plans to build an athletic club. About $2,000,000. Architect not selected.

O., Columbus—The Columbus Ice & Coal Co., Hudson and Pennsylvania Aves., is in the market for two high speed ice manufacturing machines. Ray R. Smith, Owner.

O., Elyria—The Elyria Savings & Trust Co. plans to build a 7 story, 52 x 113 ft. bank and office building, here. About $300,000. Walker & Weeks, 1900 Euclid Ave., Cleveland, Ohio, Archt.

O., Middletown — The Middletown Hotel Co. will soon award the contract for a 6 story, 130 x 168 ft. hotel building, including a steam heating system, here. About $300,000. Frank L. Packard, Hayden Bldg., Columbus. Archt., J. M. Iseminger, Pres.

Ind., Ft. Wayne—The Bd. Educ. plans to build a 2 story high school addition. About $400,000. Chas. R. Weatherhogg, Citizens Trust Bldg., Archt.

Ind., Peru—The Bd. Educ. plans to build a 2 story high school here. About $245,000. Bass, Knowlton & Co., Hume Mansur Bldg., Indianapois, Archts.

Mich., Ecorse—The Hinkley Motors Corp., 3420 West Fort St., had plans prepared for a 1 story, 52 x 60 ft. power house including one 60 hp. boiler and two 100 hp. boilers together with stock, breeching, air compressors, etc., on Cicotte Ave., here. Albert Kahn, Marquette Bldg., Detroit, Archt.

Mich., Wyandotte—The Bd. Educ. will soon award the contract for a 3 story high school, including heating and ventilating system, on Eureka and 5th Sts. About $500,000. B. C. Wetzel & Co., 2317 Dime Bank Bldg., Detroit, Archt. E. Haas, Secy.

Ill., Chicago—The Sisters of Charity of the Blessed Virgin, c/o Francis B. Byrne, Archt., 104 South Michigan Ave., are having plans prepared for a 3 story high school on Irving Park Blvd. and Lincoln Park Ave. About $1,000,000.

Wis., Wausau—St. Mary's Hospital will soon award the contract for a 4 story hospital addition and 1 story boiler house. About $275,000. E. Brielmaier & Sons Co., 432 Bway, Milwaukee, Archts.

Minn., Minneapolis—Miller & Sherman, 26 Washington Ave. South, are having plans prepared for the construction of a 5 story hotel including a steam heating system on 2d Ave. South and Washington Ave. About $250,000. Lisbenberg, Kaplan & Martin, 617 McKnight Bldg., Archts.

Minn., St. Paul—The Archdiocese of St. Paul is having plans prepared for a seminary building including a steam heating system along Lake Johanna here. About $500,000. Austin Dowling, Archbishop. Maginnis & Walsh, 109 Boylston St., Boston, Mass., Archts.

S. D., Redfield—The City will receive bids until July 8 for a reservoir, to have a capacity of 1,000,000 gals., and a pumping building. About $45,000. Cory & Le Cocq, Aberdeen, Engrs.

Mont., Bozeman—The State Bd. Educ., Helena, is having plans prepared for a heating plant in the proposed engineering building here. About $50,000. Fred Wilson, Archt.

Mont., Missoula—The State Bd. Educ., Helena, is having plans prepared for a heating plant in the proposed library here. About $50,000. Bakke & Forbes, Archts.

Mo., Clinton—G. Hart, City Clk., will soon award the contract for improvements to the light plant, including installation of boilers, new electric units, etc. About $34,000. H. C. Allen, Engr.

Tex., Taft—The Taft Packing Co. will soon award the contract for a 2 story, 65 x 115 ft. mill, fertilizer house and addition to its boiler house. H. S. Green, 415 Euclid Ave., San Antonio, Archt.

Okla., Fairfax—The city pans an election to vote on $40,000 bonds to extend the distributing system and install pumping equipment. V. V. Long & Co., 1300 Colcord Bldg., Oklahoma City, Engr.

Okla., Muskogee — The Bacone Indian University is having plans prepared for 35 college buildings. About $5,000,000. Dawson & Bassham, Archts.

Okla., Pryor Creek—The city has had plans prepared for a water purification plant including 750,000 G.P.D. duplicate units, electric pumping equipment and an 8 mi. transmission line along the Grand River 2 mi. southeast of here. About $75,000. 1300 Colcord Bldg., Oklahoma City, Engr.

Que., Verdun—C. E. Ghysons, City Hall, Engr., will receive bids until July 15, for equipment for the Pub. Wks. Dept., about $9,700; motors, switchboards and connections to electric light system, $18,465; additional motor at sewerage pump house, $2,000. Total cost about $30,000.

Ont., Beachville — The Beachville Co-operative Creamery plans to build a creamery including refrigerating equipment on Main St. About $50,000. G. J. Cook, Pres.

Ont., London—The Chairman and Members, No. 2 Committee will receive bids until July 21 for the installation of 4 sewage pumps and complete electrical equipment. H. A. Brazier, Engr.

Ont., Walkerville—The School Bd., c/o G. T. Dixon, is having plans prepared for a 2 story school including separate boiler room and power house, on Huron St., here. About $450,000. Boyd & Thompson, Windsor, Archts.

CONTRACTS AWARDED

Conn., New Britain—The Hart & Cooley Co., Inc., Corbin Ave., has awarded the contract for a 1 story, 40 x 50 ft. boiler house on Corbin Ave. to the Wm. H. Allen Co., Hungerford. About $10,000.

Conn., New Haven—The New Haven Hospital, 330 Cedar St., has awarded the contract for a group of hospital buildings including a nurses' home, children's ward, service building, etc., to Sperry & Treat Co., 39 Church St., at $1,000,000. Noted March 1.

N. Y., New York—The Beth Israel Hospital Assn., Inc., 30 East 33d St., has awarded the contract for a hospital at 10-18 Livingston Pl. to G. Richard Davis, 30 East 42d St. About $2,500,000.

Mich., Detroit — Temple Beth El, 3414 Woodward Ave., has awarded the contract for a 5 story, 121 x 200 ft. temple including steam heating equipment, etc., on Woodward Ave. and Gladstone St., to the Brayton Eng. Co., 907 Kresge Bldg., at $500,000.

Mich., Traverse City—O. C. Moffatt, City Clk., will receive bids until July 13 for developing the hydro-electric power system here. About $247,000. Fargo Eng. Co., Jackson, Engr.

Wis., Neenah—Jersild Knitting Co., 331 North Commercial St., has awarded the contract for an additional story, 50 x 200 ft. factory, to C. R. Meyer & Sons, 50 State St., Oshkosh. About $42,000.

Wis., Milwaukee—The Quality Products Co., 638 Arthur Ave., has awarded the contract for a two story, 50 x 65 ft. cold storage plant to Meredith Bros. Co., 1043 Kinnickinnic Ave. About $40,000.

Ia., Dumont—The city has awarded the contract for a sewer system and pumping station, to the Dearborn Constr. Co., Waterloo, Ia., at $50,000.

Kan., Lawrence—The state has awarded the contract for a 2 story, 76 x 118 ft. power house at the University here, to the Collins Bros., 536 Rialto Bldg., Kansas City, Mo., at $82,077. Noted June 14.

Kan., Osborne—The city has awarded the contract for a new power plant to F. A. Rosenberger, Osborne. About $75,000. Noted April 5.

Neb., Pawnee City—The city has awarded the contract for building a stack on electric power plant here, to The Merkle Mach. Co., 508 Inter-State Bldg., Kansas City, Mo. About $75,000. Noted June 14.